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FOREWORD

The concern for climate change at the international level dates back to the end of the 1970s with the organisation of the first World Climate Conference, which opened the way to many intergovernmental conferences organised from the mid-1980s. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide the world with a state of knowledge on climate change and its impacts. Its first report released in 1990 confirmed the scientific evidence for climate change and the risk posed by human activities on the environment, playing an important role in the discussions on a climate change convention. The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 during the Rio Conference. It represents the basis for a global response to climate change. It was expanded in 1997 with the creation of the Kyoto Protocol, that sets binding targets for industrialised countries to reduce greenhouse gas emissions by 2012.

Climate Change affects both the environment and human beings. The strategies to mitigate this phenomenon and to adapt to its consequences also impact on the natural and built environment and on populations, be it through the implementation of wind farms, the adoption of a fuel tax or incentive measures for sustainable construction.

While global in its nature, climate change has differentiated impacts at the local level, thus requiring a wide array of solutions to respond to the particularities of each situation. In many ways, climate change represents an obstacle to sustainable development but it can also represent the opportunity to rethink consumption and production patterns, to imagine alternatives to non-renewable sources of energy and to develop new technologies.

The Kyoto Protocol requires industrialised countries to meet their greenhouse gas emissions reduction targets primarily through national measures, while providing for international flexible market-based mechanisms (emissions trading, clean development mechanism, joint implementation). Over the years, we have witnessed a shift from mitigation to adaptation strategies, the two approaches now being advocated and combined. Indeed, it was recognised that it would be very difficult to limit an additional rise of GHGs to a satisfactory level and that negative impacts of climate change will actually occur. Current international discussions deal with these two approaches. On mitigation, climate scientists estimate that the world must cut its emissions by 80% by 2050 to limit global warming to a 2°C average rise compared to pre-industrial levels. Although it seems difficult, not to say unrealistic, to reach this objective, islands states and some African countries are even worried that such an increase in temperature will still have very harmful effects on them, pushing for a limit to 1.5°C. On adaptation, the “developing” countries will be more severely affected by climate change and the largest efforts will be required in the South. In both cases, technology transfer and financing will be crucial. Relationships between the “North” and the “South” in multilateral negotiations have been particularly tense and have been articulated around three main issues: the inequality in responsibility (and the differentiated capacities and commitments), the inequality in vulnerability (and the nature of assistance required) and the inequality in the power of influence (questioning multilateralism).

Position of key actors like China is crucial to observe and understand. China has now overtaken the United States as the world’s largest producer of CO₂, and it has a growing economy. Important emissions reduction efforts are thus expected. For its part, China argues that it is not responsible for past emissions, that it is not a big GHGs emitter on a per capita basis and that a large part of its population still lives in poverty, which requires more

development efforts.

Climate change is a truly global phenomenon, not only in geographical terms, but also because it affects every sector of society and populations groups. For instance, COP meetings gather groups that go beyond environmental NGOs, UN institutions and carbon credit certification agencies, to include organisations and industries such as Transparency International, Caritas and faith-based organisations, as well as Monsanto.

The Construction industry contributes to Climate Change (for example, the energy used by the construction, occupation and operation of buildings represents almost 50% of the UK GHGs emissions). So it has a crucial role to play, and it is important to understand the value of assessments methods such as BREEAM, CEEQUAL and LEED on carbon efficiency and the difficulty measuring carbon emissions throughout the construction life cycle. Corporate Social Responsibility is a voluntary initiative that addresses social and environmental impacts of businesses' activities. It is often a response to external and internal pressures (image, visibility, accountability), but it can also give a competitive advantage to companies. Adapting to climate change and reducing carbon emissions represent challenges, but also benefits, for industries. Research and academic institutions are also very concerned by Climate politics. Not only do they play a crucial role in conducting research on the climate system and on the social, political and economic aspects of climate change, but universities increasingly position themselves as places to both raise awareness of sustainability issues and to improve environmental performance through the implementation of green campuses.

The International Conference on Socio-Political and Technological Dimensions of Climate Change (co-organised by Housing Research Centre of UPM and UCLan Centre for Sustainable Development) aimed to explore these crucial issues through an interdisciplinary approach. Drawing on the success of the 1st Revisiting Climate Change Conference, and bringing both academics and practitioners to share their views and experiences, discussions were inclusive but not limited to the following three themes:

1. International Socio-Cultural and Political Issues;
2. Climate Change and Technology;
3. Corporate Social Responsibilities.

1. International Socio-Cultural and Political Issues

Climate Policies need to be endorsed by all sectors and actors of the society to be efficient. They also need to take into account the most vulnerable groups. Due to their cultural specificities, their marginalisation, a way of life often strongly linked with the natural environment and a dependence on natural resources, indigenous peoples and some ethnic minorities can be highly vulnerable to climate change. What are the threats faced by indigenous peoples and ethnic minorities in terms of global warming? What is their position on this issue? How do they mobilise at the national and international level? What are the international and national approaches for their protection? How should socio-cultural elements be integrated in programmes addressing climate change impacts? What can we learn from their knowledge and experience? Climate scepticism has also increased recently; how to explain this phenomenon? How to communicate on Climate Change? And how to increase the social acceptability of climate measures?

2. Climate Change and Technology

Technological innovation is seen as a requirement for both mitigation and adaptation to climate change. What types of new technology are required? What is the state of research on this subject? How can new technologies respond to climate change and its impacts? Are there alternatives? How is the Construction industry positioning itself? What is the value of assessment methods such as BREEAM, CEEQUAL and LEED? Does the nuclear industry provide a sustainable answer? Are global warming and the global environmental crisis conceived in overly technical terms? Would a move towards a change in consumption and production patterns be a better option? Would this be feasible? How will low carbon technologies be transferred from the North to the South? Through what type of collaboration and institutions? What will the intellectual property issues be?

3. Corporate Social Responsibility

Corporate Social Responsibility (CSR) is a voluntary initiative through which businesses integrate social and environmental concerns into their business operations. Why do industries decide to get a CSR policy? Does it provide a competitive advantage? How to differentiate between genuine consideration for the environment and green-washing? Universities take the lead in terms of climate research but they can also play a key role in arising concern for environmental issues and in operationalising the sustainable development agenda through the implementation of environmentally friendly and low-carbon measures. What efforts have been made so far for the promotion and implementation of green campuses? How can universities reduce their energy consumption? How can they reduce their waste? Are products used for catering grown locally? What types of transportation schemes are implemented? In terms of teaching, are climate change and sustainability issues included in all curricula? As for research, are all disciplines equally represented in climate change research? What is the weighting of social sciences compared to natural sciences?

The Editors

PART 1: INTERNATIONAL SOCIO-CULTURAL AND POLITICAL ISSUES

1 Analysing the Literature for the Link between the Conservative Islamic Culture of Saudi Arabia and the Design of Sustainable Housing

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Abstract: Saudi Arabia experiences housing shortage for mid and low-income families, which is caused by rapid population growth. This condition is worsened by the fact that the current housing supply has problems in meeting both sustainable requirements and cultural needs of those families. This paper aims to investigate the link between the unique conservative Saudi culture and the design of sustainable housing, while keeping the housing cost affordable for mid and low-income families. The paper is based on a review of literatures on the issues of the Islamic culture and how can they be integrated into the design process of a Saudi house. Findings from literature review suggest several design requirements for accommodating the conservative Saudi Culture in low cost sustainable houses. Such requirements include the implementation of proper usage of windows, and house orientation with a courtyard inside rather than facing the main street will provide natural ventilation while maintaining privacy. The main contribution to the body of knowledge is that this is a new approach to sustainable housing in Saudi Arabia considering not only energy use and architectural design issues but also socio-cultural issues as an essential part of sustainability.

Keywords: Saudi Arabia, Islamic Culture, Saudi Culture, Sustainable Housing, and Privacy.

1.1 INTRODUCTION

Housing is an essential need for human life (Gamboa, 2008, p. 4). In traditional societies, housing simply meant shelter. In these societies, housing was emphatically efficient, compatible to the surrounding environment and socially fitting (Mubarak, 1999). In other words, shelter had a close relationship with survival. But with the development of human society into what it has become today, we find that housing and land have evolved into something more than a basic necessity for survival. They have become somewhat of a statement of social stamina instead. People perceived land and housing as social resources rather than market commodities. As a result, the provision of housing has become more complex rather than easier. Various factors dictate efficient housing designs that can cater for both cultural and social needs. Some factors include economic resources, government policies, and the level of institutional and technological advancement, among others (Mubarak, 1999).

In the Kingdom of Saudi Arabia, economical developments due to the discovery and commercial exploitation of oil in the 1930s coupled with the rising market demand in the 1970s transformed traditional societies into lifestyles similar to those in many developed societies (Mubarak, 1999; Bhzad Sidawi, 2008). As a result, population in Saudi Arabia's main urban centres increased tremendously, thereby causing fast urban growth. The Saudi Arabian cities are the fastest growing cities in the Middle East (Gamboa, 2008, p. 4). Within a period of 42 years (1950-1992), Saudi Arabia's urbanisation level advanced from as low as 10% to 75% (Library of Congress, 2011). Cities such as Riyadh grew tremendously, hence bearing both sweet and bitter fruits for Saudi Arabia (Al-Hemaidi, 2001; Gamboa, 2008). Results from the 2009 census reveal that the kingdom had about 28,686,633 inhabitants. Among these, Saudi nationals accounted for 80.5%. (CIA World Factbook, 2011).

This tremendous growth caused strain in various sectors of the Saudi Arabian economy (Mubarak, 1999). According to Mubarak, the first sector to experience this strain was the housing sector. The tremendous increase in demand for new and advanced housing units prompted the use of modern architectural construction methods and design styles. Mubarak suggests further that the prominent modern styles included the western-styled Villa and multiple story apartments. However, the problem of housing shortage persisted, especially among low-and mid-income earners (Gamboa, 2008, p. 4). According to Gamboa, even when one managed to secure housing, it was neither sustainable, nor efficient in the provision of cultural needs of the occupants. And according to Hamed (2003) designing sustainably is no longer a luxury addition to a building, it is now vital to the survival of the present generation and those yet to come.

Through literature, this paper establishes the link between Saudi Arabia's unique conservative culture and sustainable housing design while maintaining housing costs affordable to mid and low-income families. This study will be looking at only the multifamily detached housing units. It explores various literatures on Islamic culture issues and the ways in which designers can integrate them into Saudi house design. Some of the literature that will be investigated include Daneshpour, A. 2011, El-Shorbagy, A.M. 2010, Hamdy, K. 2000, Hamed, S.E.A. 2003, and Kamaruzaman, J. & Siti, A. 2011.

Various architectural elements were explored as to how they can be incorporated into the design of a Saudi house that can help improve the sustainability of the house. Such elements that will be discussed include the courtyard, windows and where they are positioned and the use of the Mashrabiya, segregation in design and the use of natural elements such as natural lighting and natural ventilation. Some of the literature that will be investigated regarding these issues include AL-Rimmawi, H. & Bhardwaj, S. 2007, Aleqtisadia 2009, Alghamdi, A. 1995, Mabrouk, M. 2006, Mahmud, S. 2009, Samuels, W. 2010, And Sidawi, B. 2008. Finally, recommendations are offered for possible design requirements to be incorporated into the Saudi building sector, which can accommodate the conservative culture of Saudis in sustainable low-cost houses.

1.2 CONSERVATIVE ISLAMIC CULTURE OF SAUDI ARABIA AND SUSTAINABLE HOUSING DESIGN

For a long time, the delivery of housing products to Saudi residents has utilised a traditional approach because demand for housing in Saudi Arabia emerged due to variation in level of income and population growth (Mahmud, 2009, p. 69; Bhazad Sidawi, 2008). It regards cost reduction as the main factor and disregards the other factors (A. M. Salama, 2006, p. 67). According to Sidawi (2008), the designers have neglected the Saudi's cultural norms, lifestyles and traditions. Sidawi (2008) suggests that incorporating these dimensions into housing design decreases the overall cost of the product, its lifetime cost (maintenance and running cost, renovation and alteration expenses). This would affect property life and the user's life positively. Therefore, housing designers bear the responsibility of providing tailored and sustainable housing that meets user needs, while the users bear the responsibility of using the houses in a sustainable manner (Gamboa, 2008, p. 4). This section explores Saudi Arabia's Islamic culture, linking it with sustainable housing designs.

1.2.1 *Conservative Islamic Culture of Saudi Arabia and Dwellings*

The Saudi culture is defined by the teachings of Islam and is governed by what the Qur'an and the Hadith (Sayings) of the prophet Mohammed (Peace Be Upon Him) state. In Islam,

the Holy Quran and the Sunnah (Prophet Mohammed' s deeds and sayings) are the guidance for all Muslims in every aspect of their daily life. Therefore, it is imperative that what is learned from the Holy Quran and the Sunnah is reflected by the essential design of the Muslims' houses.

The culture of Saudi residents is a family oriented culture, where three to four generation may live under one roof. The elderly are respected and are considered the wise members of the family and are also considered the head of the family (North & Tripp, 2009). With this multigenerational household in mind, it is evident that the Saudi house would be larger in scale as opposed to those where a single family live in a two bedroom unit or similar.

Segregation is also an important Muslim value, which house design should incorporate. Muslim culture advocates for segregation, especially women from public life in the streets. This fact is true in Saudi Arabia where the segregation between male and female sections in a house is typical and mandatory to follow the Islamic ways of living.

According to Mahmud (2009, p. 4), privacy is paramount in the design of housing for occupants ascribing to the Muslim culture. In this culture, privacy, especially for women is extremely imperative. "Privacy in Islamic culture defined in three main areas: Privacy between the neighbors dwelling as well as between the individual dwelling and the street, Privacy between the sexes and Privacy between individual family members of a dwelling." (Daneshpour, 2011).

1.2.2 Conservative Islamic Culture of Saudi Arabia and Mosque Community

The cultural and religious background of a person determines how far they would live from a Masjid (Mosque), which also affects the design of a Saudi house in many ways. Since it' s obligatory for a Muslim to pray five times a day, closeness to a Masjid became a requirement in the Saudi culture. Traditional neighbourhoods were all centered on a central large Masjid, which was most generally surrounded by many of the village or town' s needs. The Masjid grew from simply a center for worship, in to the place to discuss important issues or find access to many of the townsfolk' s needs. Figure 1 shows a satellite image taken from the city of Riyadh where it shows how many Masjids are in a small area of the city, hence this illustrates how living near a Masjid is significant to the Saudi population.



Figure 1: The importance of a Masjid in a neighbourhood in Saudi Arabia

Traditionally, one large Masjid would suffice for the whole town, which had several advantages. One main advantage was that the whole town could see each other and asks about each other' s wellbeing. Another advantage was that it became a place to make announcements to the local community as they all prayed in the same Masjid.

Nowadays, one can find several Masjids in one square kilometre. This has more disadvantages than people would realise. One of the many disadvantages of having so many Masjids in one neighbourhood is that people don' t interact with one another as they used to in previous times. Another disadvantage is that there is no regulations against how many Masjids can be built in one neighbourhood, which affects the interconnectivity of the residents of any neighbourhood.

1.2.3 Conservative Islamic Culture of Saudi Arabia and the Environment

The environment is a sensitive component in Islam (AlGhamdi, 1995). As a result, the Muslim culture requires housing designs that show concern for the surrounding environment (Syme, et al., 2002). According to Syme et al (2002), Muslim culture requires every believer to show respect for benefits acquired from animals, land and forests because they come from Allah' s blessings. In other words, a believer should not abuse natural resources through the direct or implied impacts of their actions (Swanson, 1996). According to Swanson (1996), Islam is completely adamant that people should not utilise natural resources to the resource extent alone. In fact, utilising a natural resource to the resource extent alone is tantamount to committing sin. Thus, it is important to protecting and keeping the environment for only the benefits that Allah exclusively intended for Islam.

According to Champan et al. (2000) "Because Islam is a comprehensive way of life, with God-consciousness permeating all of human activity, whether it be business, education, social conduct, or science, religion and science become inextricably bound in God' s creation. Thus, from an Islamic perspective, the environment, consumption, and population are no different whether viewed from a religious or a scientific angle" . Hamed (2003) further enforces Chapman' s et al (2000) statement by stating "Islam as a paradigm and a system of life provides a distinct view of the role of man on earth and of the ownership of resources. Associated with this view are sets of unique values that are different from those of the West

and other world cultures. Also, Islamic jurisprudence provides specific laws and standards that govern the management of all environmental resources” .

In the Muslim culture, light is a symbol of divine unity. The Quran itself describes God as the light of the earth and the heavens (Qur'an Nur 24:35;(Kamaruzaman & Siti, 2011, p. 46). Just as light gets nothing from a shadow, the reality of things extends to the sharing of the light of existence. Viewing light directly creates a blinding effect. However, people use harmony in colours to define nature, which, in itself carries every visual phenomenon. Therefore, Muslim artists aspire to transform their designs into vibrations of light. In architectural designs incorporating Islamic culture, light plays a decorative role by creating patterns or modifying various elements.

With the religious aspect of the Saudi culture in mind, the designers should incorporate the needs of the Saudi population into the design of their houses. As it is unmistakable that segregation between males and females is obligatory, designers should respect this fact and integrate isolated sections for both sexes so that comfort can be attained for both inhabitants of any Saudi house. Other characteristic of design that originates from a religious point of view is privacy. Although privacy should be achieved in any house around the world, achieving it in the Saudi culture is imperative to the comfort of residents of any Saudi house. Such characteristic can be achieved by designing windows that have Mashrabiya installed on them or by other means that will be discussed later on. The Mashrabiya is a traditional wooden mesh that is installed over a window, which lets in light and air but gives the inhabitants a well sense of privacy as well (see section 3.3).

1.3 DESIGN ASPECTS FOR THE CONSERVATIVE ISLAMIC CULTURE OF SAUDI ARABIA

This part of the paper discusses some of the design elements that can contribute towards the sustainability of the housing needs of the unique conservative Islamic culture of the Saudi population. The discussion here will focus on the relativity to a Masjid and how to design the neighbourhood around it in a sustainable way. Other aspects of design will also be discussed that are vital include achieving privacy, entrances and windows, segregation, the use of natural elements such as airflow and natural lighting and integrating them into the design, and finally courtyards.

1.3.1 Relativity to a Mosque (Masjid)

As discussed earlier regarding the importance of a Masjid to the conservative Saudi Muslim culture, it is imperative that urban and city planners and architects merge their knowledge and efforts with the city councils to regulate how many Masjids can be built in one neighbourhood and how far they should be from one another. One of the many ideas that the Saudi Planning and Rural Affairs Ministry should consider, is to localise one main Masjid for the one neighbourhood where the five prayers can be performed as well as the Friday prayer and other religious occasions such as the Eid. This Masjid is located in neighbourhood centre which provide all the neighbourhood' s needs ranging from government offices to commercial outlets. Therefore, the neighbourhood would be intact and the resident in each neighbourhood would not have to travel far distances from one side of the city to the other to fulfil his or her needs.

There are many advantages that can be the outcome of such a breakthrough in the Saudi

sustainable neighbourhood design. One main advantage is that it will immensely reduce the need for using cars and other means of travel because the entire neighbourhood's needs are within walking distances. Another advantage is that the whole neighbourhood would interact with each other and they will cater for each other's needs because all the members of that neighbourhood would be generally informed of any missing need or requirement of their neighbourhood.

In utilising this concept of localisation of each neighbourhood's requirements and needs, architects and city planners have to consider how to design the Masjid and its location and the surrounding amenities so that it is within reasonable walking distance from the farthest house in the neighbourhood. Some design features have to be considered in order for this concept to triumph, such as the use of shading devices to cover the pedestrian pathways to create a pleasant comfortable environment for the walking neighbourhood. This concept would encourage the residents of the neighbourhood to go out more often and utilise these walking areas for exercise or to mingle with other members of their neighbourhood. But it is vital that all safety requirements must be taken into consideration and implemented into the design for making these neighbourhood centres safe and enjoyable for its users.

1.3.2 Privacy

A typical Saudi home (Figure 2) is designed to be as far away from the public's eyes as possible. "From a Saudi point of view, the ideal home is a self-contained villa away from the peering eyes of neighbours. High walls typically surround Saudi houses. Within the walled area, houses of extended families may be connected to each other in what resembles a walled estate." (North & Tripp, 2009). This is why in any Saudi street the typical skyline would be of high fences surrounding homes, such that the design of the house might not even be noticeable, except from within the boundaries of that fence. Hence, lots of efforts are put into the elevations of a house, but opening an opportunity for great courtyard designs that could be of great value to making the house a more sustainable one.



Figure 2: A typical example of a Saudi villa ("Example of a Saudi Villa," 2012)

1.3.3 Entrances and Windows

Privacy is also achievable from the unique design of the entrance (AlGhamdi, 1995). In houses with two entrances, the main entrance should open towards the direction of a courtyard. The other entrance should be the doorway, a key external feature that should be at the ground floor position or level. The entrance preserves the family's privacy by

opening into blank wall. This orientation obstructs views from outside into the inside. Figure 3 below illustrates clearly how the concept of privacy was achieved in vernacular houses by having an L shaped entrance that leads directly into a courtyard.

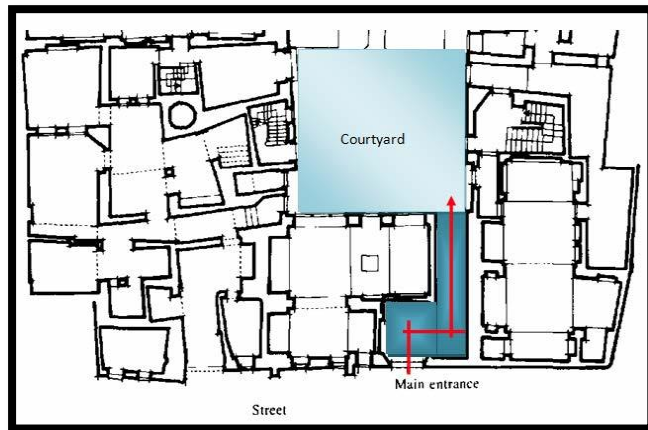


Figure 3: How to design the main entrance in vernacular houses. Obtained from (El-Shorbagy, 2010)

Other architectural elements that can contribute immensely to the comfort of Saudi house inhabitants, is the design and installation of windows that have Mashrabiya installed on them. The Mashrabiya is a traditional wooden mesh that is installed over a window, which lets in light and air but gives the inhabitants a well sense of privacy as well. But according to Samuels (2010) these Mashrabiya are no longer in use because of its economic constraints to construct and the time span to construct one. Even though of the high cost of constructing a Mashrabiya in the traditional way and the long time span that it took (Samuels, 2010) the use of light-weight material that resembles the traditional material that was used in previous times might prove to be cost effective and worthwhile. Therefore, revolutionising the concept of the Mashrabiya and considering standardising its fabrication requirements, could result in more cost effective house construction. This would require collaboration among the stakeholders of housing development. (Figure 4 and 5) illustrate some of the Mashrabiya.



Figure 4: A façade of a house that utilises the Mashrabiya (Flickr, 2010)

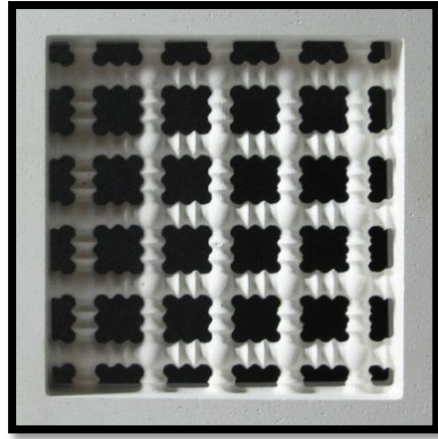


Figure 5: An actual element of the Mashrabiya (Samuels, 2010)

1.3.4 Segregation

The house design should separate private and public life, maintaining their independence. Alhazmi and Nyland (2010, p. 2) point out the importance of segregation in Saudi Arabia by stating “This phenomenon of gender segregation is central to most people’ s social, educational and political activities.” . To incorporate this belief in housing design, the housing designer should divide the house into three distinct areas: private areas for the inner family members such as the father and the mother, semi-private areas for the whole family, such as the living room. And finally, public guest zones for men. According to El-Shorbagy (2010, p. 15) the traditional Islamic-Arab house layout segregated the house between what is public, semi-public and private areas of the house. Women mainly use the private areas of the house, while men use the other parts. He also adds that the design of the house is an inward looking design where the outside walls are generally bland, which discourage strangers from looking inside. Alhazmi and Nyland (2010, p. 2) agree with El-Shorbagy and state “Saudi social life is divided by men into two separate worlds: the public world and private world. The public world is the area of business and political activity which is the man’ s domain. The private world is usually considered as a retreat and sanctuary that man should keep safe and secure” .

1.3.5 Environmental Sustainability

Sustainable housing designs for mid and low-income families in Saudi Arabia require incorporating the elements that were discussed earlier. In addition to those design elements, the design concepts must be pushed more into becoming a green design. And because of the uniqueness of the Islamic conservative culture of Saudi Arabia, it is crucial that designing firms take into consideration the client’ s needs carefully. One of the primary cost reduction solutions in the design process, that can help mid & low-income families, is to design with Green energy concepts. Green energy concepts focus on improving the energy efficiency of existing and new buildings (Roberts, 2011). This accompanies the largest, most diverse and cost-effective opportunity in building design and erections. According to Roberts (2011), the design of green buildings ensures that they adhere to specific code. Rating systems for these buildings fall in five different categories: indoor environment, materials, energy, water and site.

Although the technologies and practices adopted by most architectural designers in green

buildings differ from one region to another, fundamental principles exist (Kamaruzaman & Siti, 2011, p. 46). For instance, they exist in design efficiency, energy consumption, and water and material use. According to Mahroum (n.d.), green buildings decrease energy consumption by approximately 30%, water consumption by 30% to 50% and 50% to 90% in cost savings. This explains the increasing global pressure on the construction sector. This pressure requires people to use concepts that are not only energy efficient, but also environmentally safe. The existence of regulation frameworks and government incentives has evoked extensive interest on the use of Green building technology (B. Sidawi & Meeran, 2011). In fact, governments are acknowledging the need to foster construction concepts that are eco-friendly. Such techniques help to: 1) save energy (water and other natural resources), 2) reduce pollution, waste and environmental degradation, and 3) implement comfortable and healthy living environments (Al-Rimmawi & Bhardwaj, 2007, p. 2).

There are serious efforts in Saudi Arabia to develop a strategy that cultivates the green energy concept (AlGhamdi, 1995; Medhat, 2001, p. 142). In 2009, the formation of the Saudi Green Building Council took place (Mahmud, 2009). This was a necessary step because the ecological footprint in Arabia is approximately 4.5, hectares /capita, almost two times the global average. Besides, Saudi Arabia features among the top 20 countries that are most environmentally challenged (Al Fadl, 2010).

A close analysis of the Muslim culture reveals that green building concept will play a vital role in sustaining the culture. This focuses mostly on their respect for nature and desire to conserve the environment (Hamdy, 2000). The fact that the use of this concept results in cost reduction implies that the houses will be cheap to purchase (Queensland Government, 2009). Thus, the mid and low-income families requiring cost effective housing with elements of the Muslim culture may benefit greatly from this concept. Therefore, the design of residential houses using this concept is a noble idea that may yield maximum benefits to both the constructor and the house occupants.

Designers can use light to integrate a dynamic character to architectural designs; the combination of shade and light (Figure 6) generates conspicuous plane contrasts and adds texture to stone sculptures, as well as brick or stocked surfaces (Hamdy, 2000). The use of light will be a cheap way of providing the best house designs that reflects the Muslim culture. Where natural light is absent, the designers may incorporate the use of artificial lighting elements, but should minimise the final cost to make the houses affordable.



Figure: 6 An interior view of KAUST in Saudi Arabia, which illustrates how to utilise light and shade to enhance the aesthetic value of the building (Meinhold, 2011)

1.3.6 Courtyard Design

The design aspect of privacy necessitates proper use of space and orientation of the courtyard. The courtyard concept was common among Muslims mainly because it satisfied their social and religious needs, especially, privacy. Additionally, the courtyard's arrangements provided their environmental needs. Accordingly, it is vital that sustaining the environment penetrates through the design of the Saudi house, which is evident in the design of the courtyard. Figure 7 below illustrates an old neighbourhood in the city of Riyadh and it is obvious that every house had a courtyard.



Figure 7: A layout of traditional Saudi houses showing courtyards in every house (Aleqtisadia, 2009)

The courtyard should face the inside rather than the main street. In vernacular housing designs, features such as high walls on roofs, door and entry area arrangement and windows create the impression of privacy. Most of the spaces should face the internal courtyard to avoid situations where the openings in adjacent buildings face one another.

In the hot dry Arab zones, which form most parts of Saudi Arabia, thermal comfort is a necessity, (AlGhamdi, 1995; Swanson, 1996). As a result, a sustainable house design should cater for this need. Besides providing privacy, the courtyard design should be such that it enhances thermal comfort within the house. The design of the courtyard should facilitate free air circulation through convection (Figure 8). In hot dry weather, the courtyard air, which should be hot due to the sun's heat at daytime, rises, to pave way for cool and dense night air flowing downwards into the court. The amassed cool air within the courtyard penetrates and cools surrounding rooms. The four walls in the courtyard provide shade during the day. According to AlGhamdi (1995), this ensures that air inside the courtyard absorbs heat slowly and maintains its coolness until late hours of the day. To maintain housing costs affordable for low- and middle- income earners, the designer should choose the size and number of courtyards fitting in the available space, and using only the available resources.

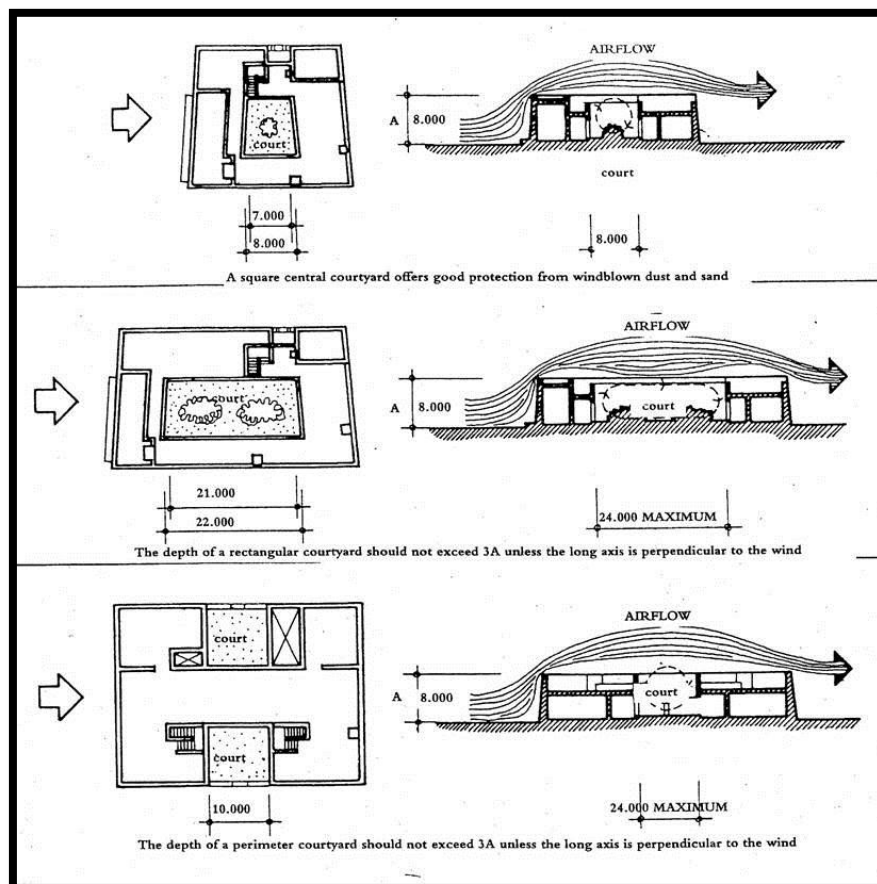


Figure 8: Airflow in a traditional courtyard (Mabrouk, 2006)

1.4 LINKING CULTURE WITH DESIGN

In this section of the paper, an attempt will be made to link the aspect of the unique conservative Islamic culture of Saudi Arabia and sustainable design. The linkage will be in a tabular format where the sustainable design elements will cross where appropriate with the cultural aspects that are discussed in this paper. The link between the cultural aspects and the design elements will range from high to low according to its importance and relativity. A rating of High means that the relativity between the cultural aspect and the design element are interconnected in a high bonded relationship where each stage of the design phase must adhere to the cultural need of the Saudi resident. A Mid rating means that the relationship between design and culture is moderate but still needs to be addressed to achieve maximum comfort of the residents. A Low rating means that the designer can combine design and culture but it is not as important as the mid and high elements of both categories that are discussed here. In summary, the unique characteristics of the conservative Islamic culture must be included in the design phase of any house to reach the desired comfort that the Saudi family requires. Each designer should familiarise him/herself with the cultural background of each Saudi family they will be designing for because references to what is important and what is not in regards to cultural aspect may differ from family to family.

Table 1: Linking Culture with Design

DESIGN	CULTURE					
		Multi-generati on	Segregati on	Priva cy	Environ ment	Light
	Relativity to a Masjid	Low	High	High	High	Low
	Privacy	High	High	/	Mid	Mid
	Entrances and Windows	High	High	High	High	High
	Segregation	High	/	High	Mid	Mid
	Environmental Sustainability	Mid	Mid	Mid	/	High
	Courtyard	Mid	High	High	High	High

It is clear that the strongest link in Table 1 is between the courtyard design and almost all the Saudi conservative Islamic culture aspects. The courtyard design will achieve not only sustainable housing but also meet the Saudi conservative Islamic culture. In addition, other design aspects can be incorporated in the building not just sustainable housing but also sustainable neighbourhood center.

1.5 CONCLUDING REMARKS

Housing is an essential need in human life. In traditional societies, it simply meant shelter and was emphatically efficient, compatible to the surrounding environment and socially fitting. In designing of sustainable housing, there is a need to address tenants' desires, that reflect their lifestyles and cultures. The incorporation or integration of these dimensions into housing design could lead to a lower overall cost of the product, i.e. maintenance and running cost, renovation and alteration expenses, and enhances sustainability. The design concepts that help to establish a link between the Saudi Muslim culture and sustainable residential housing for mid and low-income earners should include the integration of various elements in building designs, such as relativity to a mosque (Masjid), privacy, environmental sustainability, segregation of men and women in the internal and external environments, and the effective use of light.

The concluding outcome from this paper is shown in the linkage between the Saudi conservative Islamic culture and sustainable design that meets the cultural needs of low and mid-income earners in Saudi Arabia. The link between design elements and cultural aspects showed high level of connectivity between segregation, privacy, environment and relativity to a Masjid, entrances and windows, and courtyards. Other high, mid and low linkage relations were presented in section 4 of this paper. The strongest design element linked to the Saudi conservative Islamic culture was the courtyard.

This paper has clearly shown the link between the conservative Islamic culture of Saudi Arabia and sustainable design of low-rise detached houses, especially by incorporating courtyard design. This paper recommends that further research and studies are done to utilise the ideas and concepts in this paper and implement them in high-rise houses. Further studies might also include how to revolutionise the traditional concepts used in this paper such as the Mashrabiya and modernise them to be implemented into the design of a Saudi house.

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2 Transformability in Post-Earthquake Houses: Towards a More Sustainable Design Approach in Iran

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Abstract: Earthquake is one of the most calamitous disasters in Iran. The hazards of earthquake are always catastrophic not only during the disaster time but also for a long time after the disaster. Since Iran has particular financial and time constraints, hurriedly made post-earthquake emergence shelters often fail in complying with the minimum needs of the occupants. Thereby, such shelters have always been either abandoned or transformed substantially. Since the initial designs are not thoroughly tailored as to address the future's transformational needs, such transformations need comprehensive replacements in terms of structure and construction. Regardless of the other issues that could be brought by these redundant works, they are always associated with an overwhelming waste of resources. In other words, the carbon-footprint of the buildings is often increased significantly only due to not so informed initial decisions by the designers. This study explored the difficulties of the post-disaster housing transformations in Lar city, Iran as a real-life case of study. This paper reports the needs and difficulties of people for transforming their post-earthquake houses. Due to the particular economic and socio-cultural conditions of Iran, the paper proposes to integrate "short-term" and "long-term" housing reconstruction models in order to help the victims have basic but transformable houses immediately after the disaster. In other words, the paper suggests that the potential transformation must be taken into account during very early design and construction stages. The paper contributes to design research and practice and opens new avenues towards more sustainable design with respect to post-earthquake housing projects.

Keywords: post-earthquake housing, housing transformation, Iran, Lar

2.1 INTRODUCTION

Earthquake is one of the most catastrophic disasters the hazards of which are very serious within both short-term and long-term. The aim of post-earthquake housing constructions has always been to mitigate or minimise these hazards. Residential buildings have always been of the highest importance in dealing with earthquakes (Davidson et al., 2007). In essence, Alexander (1984) asserted that previous experiences in the field of human-earthquake interaction can be categorised into two groups: 1) reducing the risks and 2) mitigating the hazards. Baradan (2008) argued that although most of previous attempts mitigated the risks, they all failed in addressing people's future needs. In other words, due to the time and fund constraints of planning and constructions in force major post-earthquake circumstances, there is a risk of getting unsatisfactory results in every project (Tasa et al., 2007). This problem is further magnified in context of Iran due to its particular cultural and financial conditions (Fallahi, 2007c). Consequently, the occupants of such houses in Iran often try to transform their houses after a short occupancy period. The intention of this transformation is to adjust PEHs for fulfilling minimum life requirements. If anticipated well, the transformation process could convert these 'semi-temporary' shelters into preferable houses for people. In other words, a thoughtful initial design could leverage the latter transformations in term of adapting the semi-impermanent PEHs with residents' needs and lifestyle. Currently, the lack of information, motivation, and completed samples in Iran, usually lead to construction of some houses, which are not suitable for future transformations. Consequently, this makes the residents of such houses eventually demolish (or abandon) their PEHs. This causes

various social and economic crises in the future of post-earthquake housing process.

This study investigated the final product of post-earthquake housing transformation in Lar-Iran in order to map the problems of these transformations during a long-term occupancy. This paper reports the findings of the conducted questionnaire survey study in order to investigate three core issues of post-earthquake housing transformations in Iran: 1) the details of post-earthquake housing transformation, 2) peoples' motivations in transforming their PEHs, and 3) the influencing factors on the specifications of post-earthquake housing transformations.

2.2 BACKGROUND OF STUDY

2.2.1 Post-earthquake housing, process, planning and assessment

Barkat (2003) asserted that the success of post-earthquake housing is often dependent on the seven key factors: 1) Safety and security of land; 2) human resources in terms of unskilled and skilled labour, foremen, contractors etc; 3) institutional resources; 4) community resources and capacities; 5) availability of building materials; 6) level of available technology; and 7) financial resources. Baradan (2008) categorised these seven factors as technology-based and community-based factors. According to Baradan (2008), technology-based factors focus on building material, human resources, and technology whilst community-based factors concentrate on institutional resources and community resources.

Turan (1983) discussed two stages of housing reconstruction after disaster: 1) urgent shelters, and 2) permanent houses. During the first short-term stage of reconstruction, usually tents are setup in relief campuses (Turan, 1983). In the second stage, normal houses are constructed for a long-term inhabit. Cole (2003) developed Turan's classification by identifying two additional stages. The resultant four categories for post-earthquake housing were as follows: 1) emergency sheltering, 2) temporary sheltering, 3) temporary housing, and permanent housing. According to this category, emergency and temporary shelters are occupied during the relief period (for less than one month), temporary houses are occupied during reconstruction period (for less than two years), and permanent houses are formed in order to provide normal life for people. Arsalan developed Cole's (2003) category by adding the fifth stage which is called "*temporary housing transformation*" (Arsalan, 2007a). This model proposed a method for reusing temporary houses after occupancy. This means that temporary houses are transitional dwellings that, eventually, should be transformed into other kinds of buildings or even completely replaced by new constructions.

From a different point of view, Esin and Cosgun (2007) asserted that controlling the constructional wastes could play a very important role in making a post-earthquake reconstruction process successful. In this regard, Arsalan and Cosgun (2007) proposed use of some kinds of recyclable and reusable temporary houses in post-earthquake area. They identified two types (passive and active) of after occupancy usage for the post-earthquake temporary houses; in "*passive measures*", temporary houses are changed into permanent houses or to any other functions until the end of lifetime, whilst in "*active measures*", temporary houses or their material are sent to another area or stored for case of another disaster. Lizarralde and Root (2007) defined two types of '*passive*' reuse: 1) when a low-income family uses a temporary house with no additional part, even after construction of permanent houses; 2) residents transform temporary dwellings into permanent houses during occupancy period.

2.2.2 Post-earthquake housing problems

The urgent need of shelter for the survivors is the main issue that should be taken into account by governments and public departments (Diane Myers, 2000). The situation is even worse when there is a shortage of fund and a limited time to help the victims. Temporary houses can partly mitigate this risk (Arslana & Cosgun, 2007). However, the households never feel the sense of ownership and social safety living in this kind of temporary shelters. Consequently, these might cause some social problems in post-earthquake area if used for a long period of time (Mohammad Parva & Kamariha Dola, 2007). Long-term post-occupancy problems also could appear when household try to improve their living conditions but the house is not good enough to address their 'new' needs (Mohammad Parva & Kamariha Dola, 2007). This problem is further magnified when the PEHs are constructed by contractors without any contribution from the households (Barenstein, 2005). This study posits that long-term problems of post-earthquake area could be minimised by making PEHs capable to be modified based on households' prospective needs.

2.2.3 Post-earthquake housing transformation

Transformation in architectural studies refers to changing and modifying building into a better condition during occupancy period. It consists of changing form, function, and pattern of buildings. Mostly, building transformation takes place in residential buildings (Brand, 1994b). According to Shiferaw (1998), residential buildings are transformed more efficiently compared to the other forms of buildings. In this process, the houses are adjusted to households' life style (Shiferaw, 1998). It is often difficult to distinguish housing transformation from some other activities such as housing extension, housing renovation, and housing alteration (Salim, 1998). Votava (2006) defined housing transformation as some indoors and outdoors changes that are based on households' requirements. According to Votava (2006), housing transformation process promotes temporary shelters into the permanent homes.

2.2.4 Housing transformation as a socio-economic opportunity

Tipple (Tipple, 1996) asserted that housing transformation could contribute to sustainable developments in the urban and rural environments. According to Tipple (Tipple, 1996) housing transformation could always contribute to architectural qualities of the houses, so that it could increase households' attachment to their houses and leverage their sense of belonging. From a different perspective, Habraken (1975) argued that housing transformation could develop the quality of housing spaces and adjust social and economic conditions of living spaces. Tipple (1996) argued that any improvement in the quality of living environment needs to be done during a long-term and based on the needs, interests and socio-economic status of households. Habraken (1975) asserted that studying housing transformations could reveal the households' viewpoint about their life environments which could be developed into lifestyle approaches for designing affordable houses (Salam, 2006). Al-Naim (2008) categorised the socio-economic factors which could affect the housing transformation process as follows:

- factors that are formed by housing supply systems,
- factors that have significant impacts on existing housing resources, e.g. land, infrastructure and construction materials, and
- factors that could save social resources.

2.2.4.1 Types of housing transformation

Brand (Brand, 1994b) identified two types of housing transformation, namely “*add-In*” and “*add-On*”. In add-In transformation, the changes are done inside the existing building without constructing any additional space whilst add-On comprises of additional constructions. Consequently, add-On transformation system has the potential to expand the built area of the building (Brand, 1994a). According to Tipple (1996), in add-In building transformation, internal walls are capable to be modified based on households’ requirements so it gets hold of adjusting indoor spaces into new condition, whilst add-On transformation is done for getting larger indoor spaces.

In another classification of housing transformation, Salama (1998) categorised housing transformation into two categories namely exterior and interior transformations. According to Nguluma (2003), exterior transformation consists of changing façade, windows, and housing extensions, whilst, interior transformation refers to modifications of indoor spaces by only relocating internal walls and changing room sizes.

2.2.4.2 Levels of transformation housing

Mahmud (2007) developed Brand’s (1994b) findings in order to categorise housing transformation into four levels: *slight adjustment*, *addition and division*, *total conversion*, and *reconstruction*. Latter, Okatay and Orcunoglu (2007) added ‘*Rebuilt*’ as one more level, where the houses are changed fundamentally; normally, for transforming courtyard and terrace-houses into apartments.

2.2.4.3 Motivations for Housing transformation

Rapoport (Rapoport, 1995) claimed that socio-cultural aspirations are the main motivators for constructing the houses. Shiferaw’s (1998) developed this model and explained common motivation of housing transformation as: 1) socio-culturally determined aspirations, 2) changes in households’ structure, comprising the size and structure of the family, 3) desire to generate income (by modifying the function of housing to a commercial building), 4) reply to harsh climatic conditions, 5) desire to copy prevalent housing forms, 5) new aspiration to change traditional housing forms. Hojrup (2003) developed this theory based on lifestyle theories. Salam (Salam, 2006) added the idea of housing motivators and chaining houses to Hojrup’s (2003) theory, by analysing the impacts of lifestyle models on housing transformation. Salam (2006) further analysed all aforementioned categories of housing transformations based on three lifestyle models: *work-based*, *attitude-based*, and *status-based*. The common part of all these theories that have never changed was that all of them considered housing transformations as a result of three types of factors: 1) *architectural factors*, 2) *socio-cultural factors*, and 3) *economic factors*.

2.2.4.4 Housing transformation process

Housing transformation process determines the actual relationship among initial housing quality, transformation period, and final product (Figure 9) and the determinant factors during this process could be categorised as: 1) *physical*, 2) *functional*, 3) *financial*, 4) *architecture*, and 5) *ecological factors* (Flier, et al., 2004).

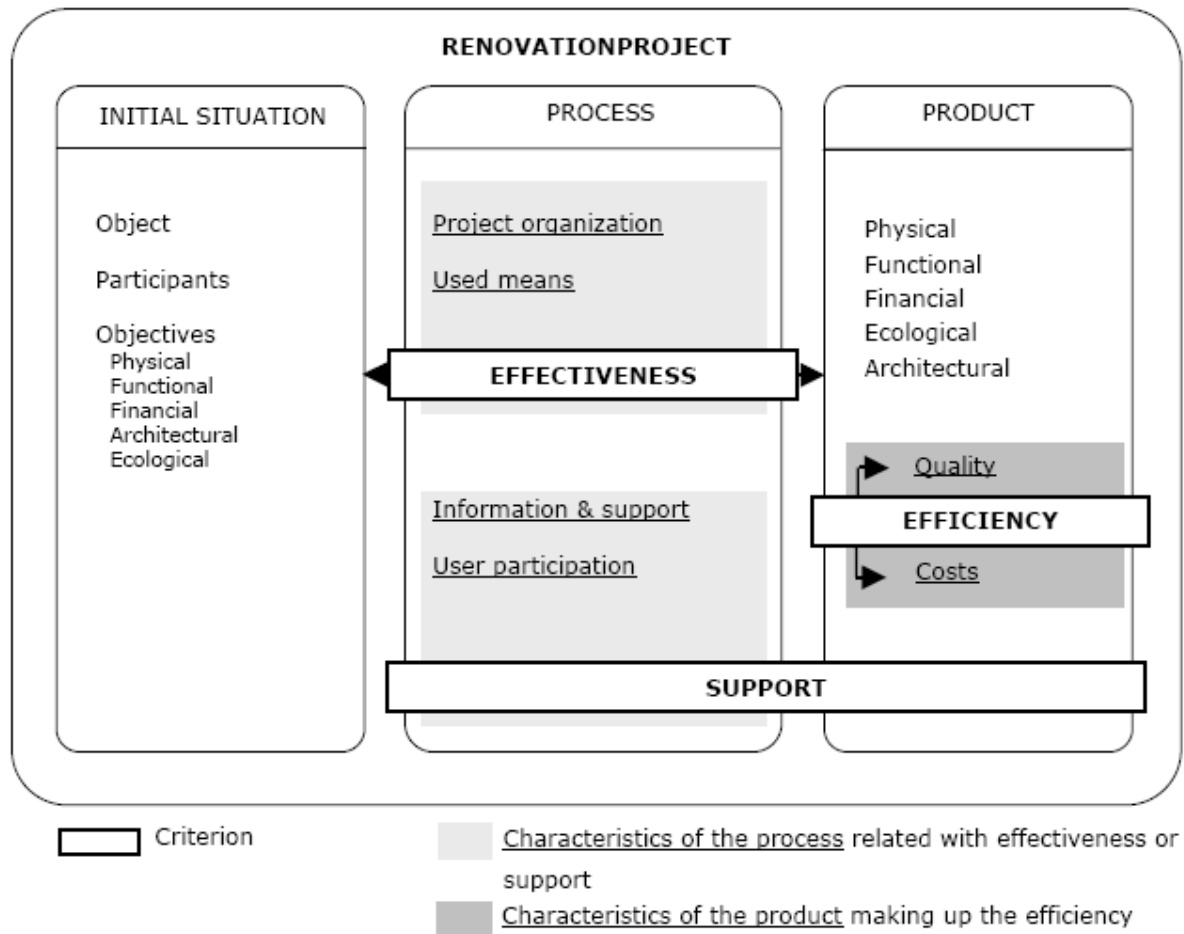


Figure 9: Housing transformation framework (Adapted from Flier, et al., 2004)

2.2.5 Housing transformation in Iran

Housing transformation is a very common phenomenon in the cities of developing countries (Mahmud, 2007). This phenomenon is more highlighted in the countries with free hold residential property ownerships. However, the highest rate of housing transformation is in the countries in which houses are considered as wealth (Popkin, et al., 2005). Notwithstanding the traditional housing transformation system in Iran which was a continual activity controlled by the household size (Memarian, 1999), modern housing transformation has become an emerging issue due to the recent huge increase in housing prices (Soltanzadeh, 2005). As such, Mirmoghtadaee (2009) chronologically categorised housing transformations of Iran into three groups: *traditional*, *transitional*, and *modern* transformations. According to this model, in the traditional period the changes were very slow and it was controlled by the changes in the size of household. In transitional period, the traditional typology of the houses has been transformed into modern houses. Finally, by influence of economic factors, the modern transformation transforms the traditional courtyard houses into apartments.

The traditional housing transformations in Iran were continuously performed during occupancy period and following the traditional housing patterns of “*Inward-looking*” courtyard houses (Memarian, 1999). In essence, a traditional house in Iran transformed in two stages: 1) first it expanded horizontally around the courtyard, and 2) then the house expanded vertically. As such, in this transformation the original dwellings (initial housing plan) were always preserved. In contrast, through transitional and modern transformations which commenced since 1970s (only in Tehran and the other four other large cities of Iran:

Tabriz, Isfahan, Mashhad, and Shiraz) courtyard houses started to transform into modern houses; and it demolished the initial housing plan of the original dwelling. Notwithstanding the risks, the Modern housing transformation in Iran is considered as a predominant policy for leveraging Iranian housing development (MHUD, 2006) for addressing the need for 600000 new residential units in Iran (Miromogtadaee, 2009). This makes it necessary to take these transformations into account as an indispensable fact of housing in Iran. This paper claims that a well-defined plan for these transformations could significantly mitigate all types of prospective risks resulted by these transformations.

Table 2 compares traditional transformations with the new methods of housing transformations in Iran.

Table 2: Typology of housing transformation in Iran, (Adapted from Miromogtadaee, 2009)

	Initial housing plan	Process of transformation	Motivation of housing transformation	Final result of housing transformation
Traditional housing transformation	Protect	Continually	Adapting house to household changing	A courtyard houses(based on the Iranian traditional housing)
New housing transformations	Demolish	Suddenly	Getting profits	Residential complex

2.3 RESEARCH METHODOLOGY

2.3.1 Context of the study, Lar City

Lar city was chosen as the context of this study for three reasons as follows: 1) completing a full lifecycle for PEHs since 1960, 2) similarity between climatic and geographical conditions of Lar and those for high-risk zones of central parts of Iran, and 3) homogeneity in original dwellings in PEHs of Lar city.

2.3.1.1 Typology of houses in Lar

Of the main characteristic of Lar city is being divided into two parts Figure 9 which were founded in different times. While the old part of Lar is a historic area the history of which backs to more than 1000 years ago, the new part has been founded only after the earthquake of 1960 destroyed a main part of the city.



Figure 10: Airplane view of old city and new city of Lar, Source: Google Earth

In overall, Lar' s pre-earthquake houses could be categorised into two different types: 1) pure-residential buildings and 2) residential-commercial buildings. Pure residential per se could be categorised into two different types, namely single-courtyard and multi-courtyard houses. Usually, in Lar' s single-courtyard houses which are built in one or two stories, all of spaces are organised around a central courtyard (*Comprehensive Plan of Lar*, 2001). In the meantime, multi-courtyard houses which are more developed than the first group of the houses, there is a distinction between “*introvert*” and “*extrovert*” courtyards. In such houses, the introvert courtyards are dedicated to service activities, e.g. traditional kitchen (Matbakh), however, extrovert courtyards are surrounded by the spaces which are designed for serving guests or attending strangers (Memarian, 1999). Residential-commercial buildings are located besides the main roads and comprise some shops as well as residential spaces. In some residential-commercial houses which belong to rich merchants, there are also some stores for storing incoming goods.

Aesthetical values and decorations of interior spaces are the integral parts of Iranian introvert architecture (Memarian, 1999). This claim can be generalised to architecture of all cities of Iran, including Lar (Figure 11). Besides, due to thermal comfort considerations, white is *de facto* colour (Figure 12) of the houses in Lar (*Comprehensive Plan of Lar*, 2001).



Figure 11: Hajj Moayed's House, Lar, Old Town, Founded in 1880



Figure 12: Hajj Mahmoudi's House, Lar, Old Town, Founded in 1880

After the 1960 earthquake (Figure 13), the government decided to construct a new town near to Lar, rather than reconstruction of the disaster site. There were two main reasons behind this decision: 1) the original city was located on a high-risk zone and 2) it was very difficult to rehabilitate the exhausted old site; consequently, the new city was founded on a land which was 4km from southern border of the original city (Figure 14) (*Comprehensive Plan of Lar*, 1985).



Figure 13: Lar earthquake-1960, Source: Iranian Red Crescent Society



Figure 14: Post-earthquake housing Lar-1961, Source: Iranian Red Crescent Society

New Lar city comprises of 48 urban blocks including 20 residential lands each. Every residential land is a 15m by 35m rectangle (Figure 15). During the first phase of this project, the government developed 375 residential units dispersed in all over the city to further motivate people to come and reside there (Kashefy, 1970). Initially, the built area of every house was 35 m² and the houses were delivered by prefabricated construction system. Due to the particular constructional system of this city, every two houses shared a single structural system (Figure 16). As it will be discussed in the next sections, this became one of the main barriers of housing transformation in this city (*Comprehensive Plan of Lar*, 2001).

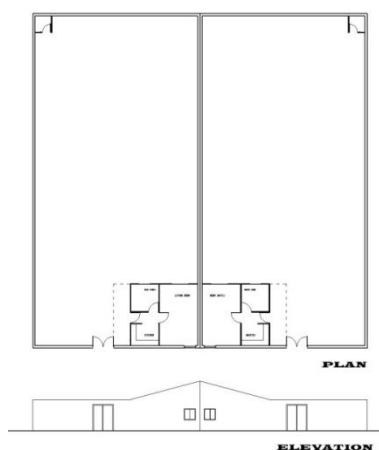


Figure 15: The floor plan and the elevation of the typical houses in New Lar city



Figure 16: Twin prefabricated houses in New Lar city

Due to the time and financial constraints in designing and constructing the new city, people faced various post occupancy problems. The main problems which were initially claimed by the people were as follows: 1) the design was not addressing the minimum thermal comfort requirements of the area; 2) the road system was very inconvenient for the users; 3) the city was very far from the original downtown and there was not any substitute facilities in the new city; and 4) the design of the houses was very alien for people of Lar (*Comprehensive Plan of Lar*, 1985). These problems led to substantial transformations in PEHs in Lar.

2.3.1.2 Housing transformation in Lar

Lar' s houses could be considered as very particular cases due to their very high prices (Kashefy, 1970). Average of house prices in 2000 was 12000000000IRR, it was 19% more than average of house price in a similar city in Iran (*Comprehensive Plan of Lar*, 2001). According to the master plan of Lar (*Master Plan of Lar*, 1991), Lar has two kinds of housing transformations. While the slow and traditional transformation in old town of Lar follows the changes in the size of households, transformations in the new city of Lar and post-earthquake area has much higher rate and impact. Although this high speed transformation process could be considered as an opportunity for documentation of the experience for future reference, there is no formal study to investigate Lar' s housing transformation process (*Master Plan of Lar*, 1991). As a result of these arbitrary transformations, the share of built area in residential properties of Lar has recently increased by more than 320%. Although the existing roads are sufficient to support the new population, there are still many problems due to unplanned transformations (*Comprehensive Plan of Lar*, 1985).

Taking into account the aforementioned needs, this study conducted a questionnaire survey in order to investigate people' s perceptions towards housing transformations in Lar' s PEHs based on four factors: 1) advantages and problems of the PEHs compared to the traditional houses in Lar, 2) advantages and problems of the transformed houses compared to the original PEHs in Lar, 3) people' s expectations that are not addressed in PEHs, and 4) motivations of people for transforming their PEHs.

2.3.2 Research variables

The variables of this research could be categorised into two groups: 1) building oriented, and 2) human oriented variables. Building oriented variables which explained housing state before and after transformation were analysed in three stages: pre-earthquake-1960 housing

process, post-earthquake-1960 housing process, and post-transformation housing process. However, the human oriented variables explained the residents' ability to perform housing transformations and their needs for transformations.

Building oriented variables could be categorised as independent and dependent variables. In this research, independent variables which represent some specifications of the buildings are as follows: 1) specifications of PEHs, 2) location of PEHs, 3) specifications of pre-earthquake houses, 4) climatic conditions. On the other hand, the dependent variables of this research are: rate of transformation, time of transformation, morphology of transformation, typology of transformation, pre- and post-earthquake facilities.

Human oriented variables, however, comprise of all socio-cultural and economical parameters of the households. These variables which can be categorised as independent and dependent variables may affect building variables too. The independent human variables of this study are as follows: household size, household's preferences about pre-earthquake house, household income, and households' viewpoint about PEH, pre- and post-earthquake facilities. However, households' perceptions towards the housing transformations are the only dependent human variables of this study. Consequently, the developed questionnaire in this study consisted of nine parts and 68 questions (see Table 3).

Table 3: Summary of the designed questions

Topic of the section	Number of Subsections	Number of Questions	Purpose
1 Household particulars	-----	8	To identify the characteristics of the household
2 House particulars	-----	4	To identify the specifications of the houses
3 PEH particulars	-----	12	To survey people's perception of PEHs
4 Post-Earthquake Housing transformation particulars	----	9	To survey people's perception of post-transformation houses
5 Influencing factors on the transformation of post-earthquake housing	3	18	To get affirmation of theories derived from literature
6 Motivation of on the transformation of post-earthquake housing	----	7	To get affirmation of theories derived from literature
7 Rate and type of transformation	----	5	To analyse quality and level of the transformations
8 Determine the degree of importance of the following actor/factors in designing PEHs	----	3	To get affirmation of theories derived from literature
9 Respondents will fill this part of questionnaire	----	2	To integrate the results of the questionnaire with findings of the systematic observation

2.3.3 Controlling the Measurement Error, Validation and Reliability

There is a potential of error in every study in which data is collected via questionnaire survey. According to true space theory, true score of a research could be calculated as summation of truth and measurement errors (Trochim, 2009). In below equation, $\text{var}(X)$, $\text{var}(T)$, and $\text{var}(E_x)$ respectively represent observation score, trough ability, and random error.

$$\text{var}(X) = \text{var}(T) + \text{var}(E_x)$$

In space theory, measurement errors comprise of random error and systematic error. Consequently, the equivalent equation could be defined as follows:

$$X = T + E_r + E_s$$

In true score theory **E_r** means Random error and **E_s** means systematic error. Therefore, random error and systematic error should be minimised in order to get more accurate result. The random error of the conducted survey was controlled by selecting an appropriate sample size. With regard to the controlling systematic error, Mansuorian (2002) asserted that three factors can facilitate the reliability of the findings in conducting questionnaire survey: 1) designing clear questionnaire for testing actual perception of people about research constructs, 2) employing different indicators with similar intention and running reliability test among the similar indicators, and 3) conducting pre-test. This research employed native people for adjusting the terms of questionnaires with local terms of Lar. Moreover, some purposive repetitions have been embedded in the questionnaire in order to facilitate future reliability tests. Finally, a pre-test survey was conducted for refining the questionnaire and

reconsidering all vague questions. Cronbach' s alpha value was calculated for all groups of questions and when the value was less than 0.6, problematic questions were detected and reformatted. Consequently, as reported in different parts of Results and Analysis section, Cronbach' s alpha values of all groups of the final test were greater than 0.6; which is the significant level for showing the reliability of questionnaire survey. In addition to considering these factors, this research also relies on the clarifications by trained distributors during the data collection phase. The distributors were architectural students who are quite familiar with this research and PEHs of Lar. This consideration was motivated by low educational background of majority of people of Lar who were not able to read and understand the questions properly. Finally, triangulation among different theories from literature review and findings of survey further assured the construct validity and internal validity of this study (please refer to the discussion section for more details).

2.3.4 Data Analysis strategies

The collected data through the conducted survey was stored in an SPSS file. SPSS version 17.0 was employed to carry out all the data visualisation and hypothesis testing tasks. The employed tests included basic Descriptive Statistics (Mean, Standard Deviations etc), Examination of Reliability Scale, and Hypothesis testing scales (e.g. Correlation Analysis and Regression, Variance Analysis (ANOVA), and Chi square).

2.4 RESULTS AND ANALYSIS

In overall, 190 questionnaires were distributed among respondent. Following sections describe the results in detail.

2.4.1 Determining people' s motivations in transforming Lar' s Post-earthquake Houses

Figure 17 provides descriptive overview for people' s main 7 motivations in transforming their PEHs in Lar. Based on this result, the most predominant motivations for transformations are *“to adjust physical-living comfort”* and *“Growing household size”* . The results also show that *“Increasing income”* and *“Thermal comfort considerations”* have the least impacts in motivating people.

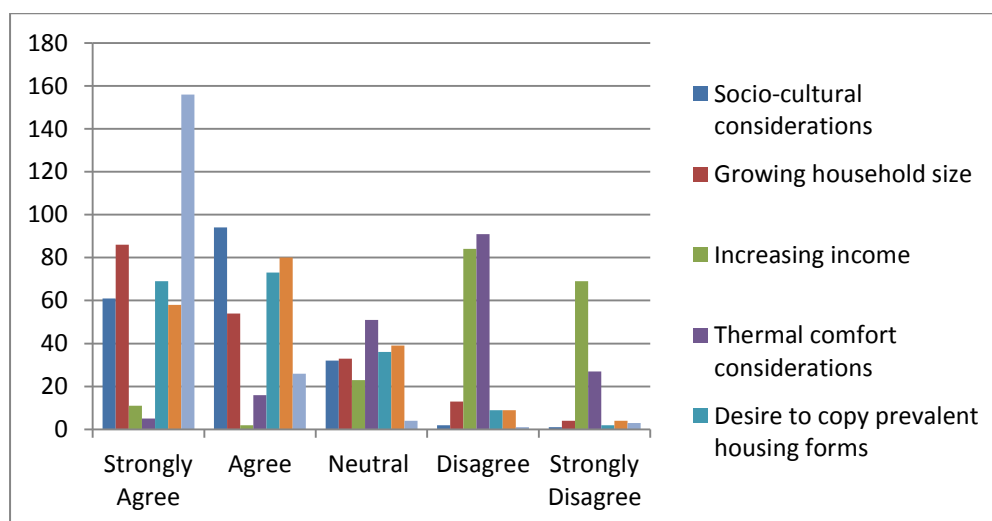


Figure 17: Descriptive analysis of people's motivations for transforming Lar's PEHs

2.4.2 Inferential statistics for people's motivations in transforming PEHs in Lar

This section firstly reports on the results of testing the hypotheses related to people's motivations in transforming PEHs in Lar, then it further justifies the impacts of each factor by conducting factor analysis. Since housing transformations are dependent on motivations for overcoming shortcomings of original dwellings, this paper looks for significant relationships between specifications of initial PEHs and people's motivations for changing them. In other words, the assumption is that the shortcomings of original dwellings motivate the transformations. Therefore, this study tested five related hypotheses:

H1: There is significant relationship between total specification of PEHs and motivation of socio-cultural considerations for transforming PEHs.

H2: There is a significant relationship between location of PEHs and motivations for transforming PEHs in order to increase household's income.

H3: There is a positive significant relationship between growth in household size and increment in people's motivation for transforming their PEHs.

H4: There is a significant positive relationship between inappropriate spatial organisations in PEHs and level of socio-cultural considerations for housing transformations.

H5: There is a significant positive relationship between desire for applying traditional architecture of Lar in PEHs and motivations for housing transformations in Lar's PEHs.

In order to test each hypothesis, this study conducted "*Pearson Product-Moment Coefficient*" for testing relationship between dependent and independent variables. For testing the first hypothesis, the study first investigated the consistency among all independent variables which are PEH specifications. The conducted reliability test revealed that the increment and decrement of the variables related to qualities of PEHs are aligned together (Cronbach's alpha value=.72). Therefore, this study combined all those variables into one single variable so called PEH specifications. The study then conducted Pearson Product-Moment Coefficient Test for testing the relationship between PEH specifications and socio-cultural considerations for transformations (H1). The conducted test confirmed the asserted hypothesis ($r = -.13$, $n = 189$, and $p < .05$). The second hypothesis evaluated the relationship between the location of the houses and emergence of motivations for increasing household's income via housing transformations. In other words, as increasing household's income is possible by converting the function of PEHs from residential into commercial buildings, this is assumed that this tendency is higher in the houses which are located in vicinity of commercial site. The result of the conducted Pearson Product-Moment Coefficient test confirmed this hypothesis ($r = .157$, $n = 189$, and $p < .05$). The third hypothesis of this section asserts that the increment in household size is a stimulus for transformations in PEHs in Lar. The result of the conducted Pearson Product-Moment Coefficient test confirms this hypothesis too ($r = .243$, $n = 189$, and $p < .05$). In a same manner the conducted Pearson Product-Moment Coefficient test confirmed H4 and H5 as

well. In other words, the tests revealed the existing significant positive relationship between the levels of people's complains against the inappropriate spatial planning of PEHs and also impacts of socio-cultural considerations in order to transform the PEHs ($r = .124$, $n = 189$, and $p < .05$). The respective test also confirmed that there is a significant positive relationship between desires to follow vernacular architecture of Lar and increment in motivations for transformations in Lar's PEHs ($r = .238$, $n = 189$, and $p < .05$).

2.4.3 Factor analysis for evaluating the impacts of each transformation motivation

A "linear regression analysis" was conducted in order to determine how much each motivational factor affects the formation of housing transformations in Lar's PEHs. The results revealed that only "socio-cultural considerations" significantly affected the formation model of housing transformations. Therefore, this study further traced the impacts of all sub-categories of PEH specifications in forming the category of socio-cultural considerations. Figure 18 illustrates the impact level of each sub-factor of PEHs specifications in forming transformation motivations. In this diagram, R^2 represents the impact level of each factor. The diagram shows that the impact of PEH specifications on formation of socio-cultural motivations for transformations is 8.5% ($R^2=0.084$). In other words, 8.5% of model of socio-cultural motivations for transformations is determined by PEH specifications. Based on this result, the most influencing factor in forming PEH specifications is the quality of spatial planning ($R^2=0.512$) whilst the lowest impact in this formation belongs to the quality of ornamental elements (1%).

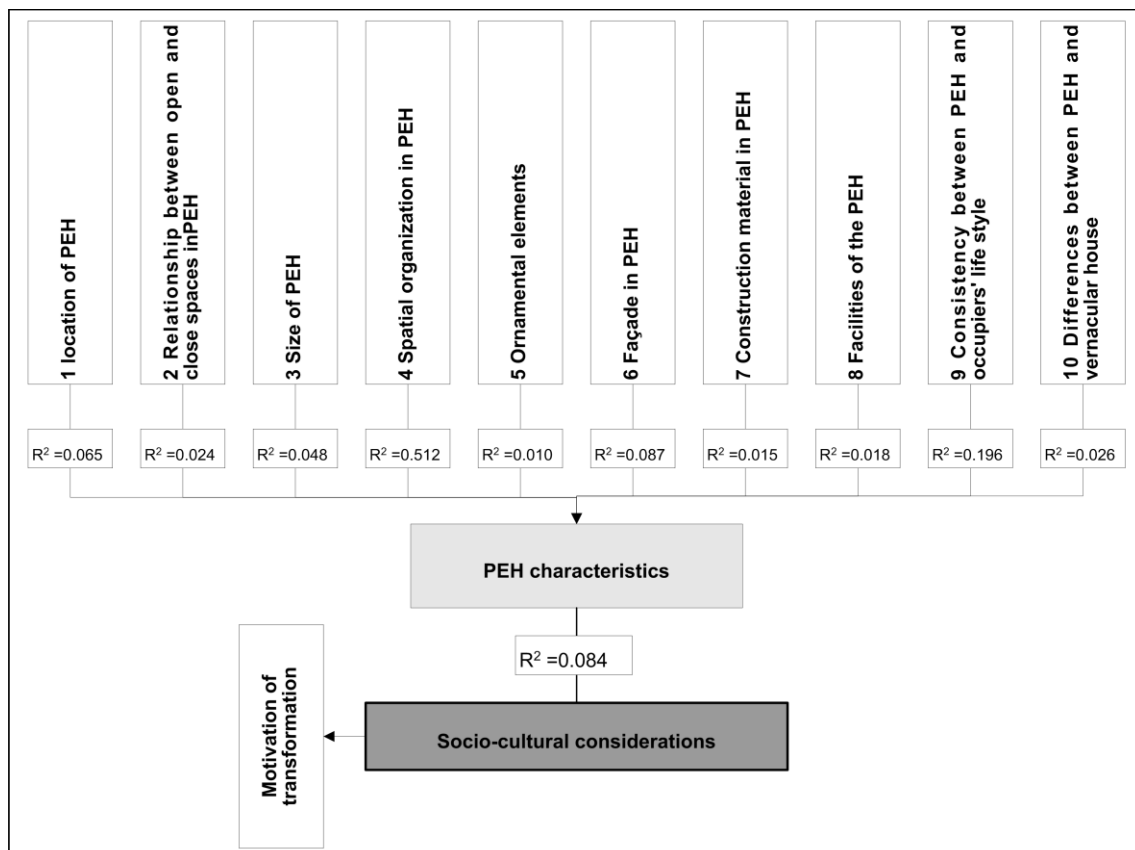


Figure 18: Analysis of impacts of post-earthquake houses characteristics on emergence of

motivations for post-earthquake house transformations.

Pearson Product-Moment Coefficient test was also conducted among all factors of post and pre earthquake houses and all motivations of transformations. The purpose of this test was to reveal the relationships between housing specifications and motivations for transformations with further details. Table 4 summarises logical relationships among specifications of post and pre earthquake houses and motivations of transformations comprising of *socio-cultural considerations*, *to follow traditional architecture of Lar*, and *to adjust physical-living comfort*. Table 4 reveals that there is a significant relationship between PEHs specifications and 2 of transformation motivations comprising of socio-cultural considerations and thermal comfort considerations. On the other hand, three of motivations including socio-cultural considerations, to follow traditional architecture of Lar, and to adjust physical living comfort are controlled by conditions of pre-earthquake houses.

Table 4: Relationships between housing specifications and motivations for transformations in Lar's PEHs.

		Socio-cultural considerations	Growing household size	Increasing income	Thermal comfort considerations	Desire to copy prevailing house forms	To follow traditional architecture of	To adjusted physical-living comfort
PEH specifications	Pearson Correlation	-.130 (*)	.106	-.018	-.118 (*)	-.033	.047	.042
	Sig. (1-tailed)	0.037	0.074	0.403	0.05	0.329	0.262	0.282
	N	190	190	189	190	189	190	190
Pre-earthquake housing specifications	Pearson Correlation	.250(**)	.055	-.005	.041	.034	.340(**)	.178(*)
	Sig. (1-tailed)	0.001	0.227	0.474	0.287	0.325	0.000	0.008
	N	186	186	185	186	185	186	186

* Significant relationship exists between two variables

** Very significant relationship exists between two variables

This study also conducted linear regression test in order to analyse impacts of each of

aforementioned factors on forming the motivational model of housing transformations. The results are shown in Figure 19. According to Figure 19, the model of motivations for housing transformations is independent from the specifications of PEHs and is only shaped by 4 out of 9 specifications of pre-earthquake houses. In the meantime, the diagram shows that the mentioned 4 characteristics significantly influence the formation of only two motivations namely socio-cultural considerations and to follow Lar' s traditional architecture.

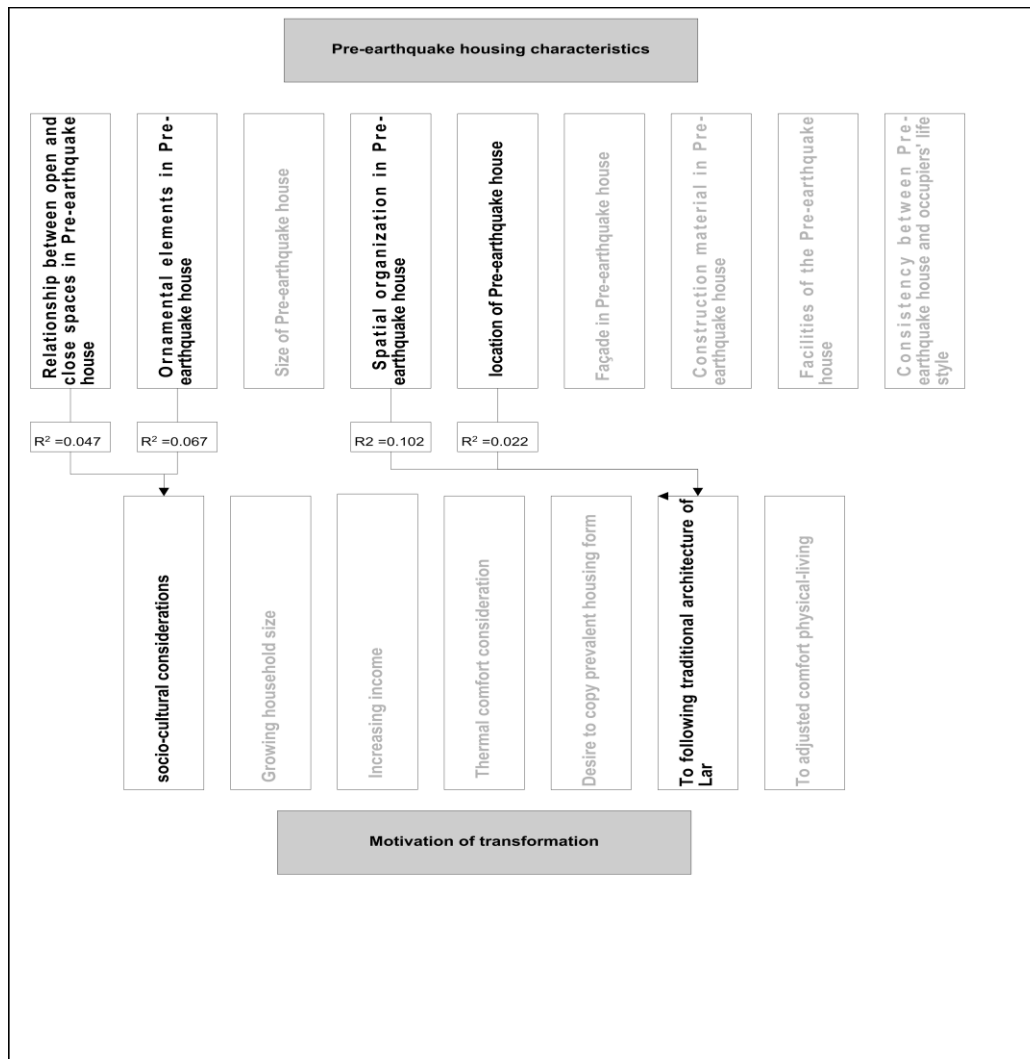


Figure 19: Analysis of impacts of pre and post-earthquake housing characteristics on forming the motivational model of housing transformations

2.4.4 Motivations for transformations and their impacts on emergence of housing transformations in PEHs in Lar

In order to examine the impact degree of each of motivations studied above in performing the transformations in Lar' s PEHs, this study conducted a Pearson Product-Moment Coefficient test for tracing the relationships among the motivations and the appeared transformations. According to the results presented in Table 5, typological transformations are significantly stimulated by socio-cultural considerations and desire to follow the prevailing international housing forms. The results also show that changes in built up are triggered by desires to follow the prevailing international housing forms. However, functional transformations are stimulated by targeting more income and desire to follow traditional

architecture of Lar. Finally, the results show that the transformations in materials and facades are caused by desire to copy prevalent housing forms and desire to follow traditional architecture of Lar.

Table 5: Relationships among people's motivations for transformations and the appeared housing transformations in Lar

		Socio-cultural considerations	Growing household size	Increasing income	Thermal comfort considerations	Desire to copy prevalent housing forms	To follow traditional architecture of	To adjusted comfort physical-
Typology	Pearson Correlation	.203(**)	-.015	.029	.070	.207(**)	.010	.113
	Sig. (2-tailed)	.005	.832	.695	.338	.004	.888	.120
	N	189	189	188	189	188	189	189
Built area	Pearson Correlation	.025	.067	-.039	.049	.199(**)	-.080	.103
	Sig. (2-tailed)	.736	.362	.593	.506	.006	.276	.158
	N	189	189	188	189	188	189	189
Function	Pearson Correlation	-.029	-.164	.435(**)	.064	.057	-.150(*)	-.094
	Sig. (2-tailed)	.692	.025	.000	.385	.441	.040	.197
	N	188	188	187	188	187	188	188
Construction al Materials	Pearson Correlation	-.093	.035	-.029	.067	.233(**)	-.168(*)	.048
	Sig. (2-tailed)	.204	.629	.689	.359	.001	.021	.516
	N	189	189	188	189	188	189	189
Façade	Pearson Correlation	-.077	.065	.002	-.021	.281(**)	-.154(*)	.048
	Sig. (2-tailed)	.291	.377	.977	.778	.000	.035	.517
	N	188	188	187	188	187	188	188

* Significant relationship exists between two variables

** Very significant relationship exists between two variables

2.4.5 Analysis of influencing factors on PEH transformations

In order to analyse housing transformations, this section first explores the architectural specifications of housing transformations then justifies independent variables (factors) which influence these transformations. The studied factors in this section are as follows: 1) tenure form, 2) original dwelling (initial housing plan), 3) financial resources, 4) employable labour, and 5) infrastructure.

The architectural factors that could affect housing transformations are as follows: 1) transformations in morphology, 2) transformations in built up area, 3) transformations in

functions, 4) transformations in construction material, and 5) transformations in façades. The conducted reliability test among all these 5 factors reveals that the rate of changes is consistent for all variables (Cronbach' s alpha value= .7825). Therefore, the study generated a new variable entitled “*Rate of transformations*” through collating above 5 variables in order to represent the average amount of transformations in PEHs. The study further analysed the impact of each of these factors on housing transformations by conducting factor analysis. The results of the conducted linear regression test for above mentioned purpose are presented in Figure 20. It could be concluded from Figure 20 that the highest impact on forming the model of transformations was made by transformations of built up area (70%). The impact of each of the other 4 factors is also illustrated in this Figure.

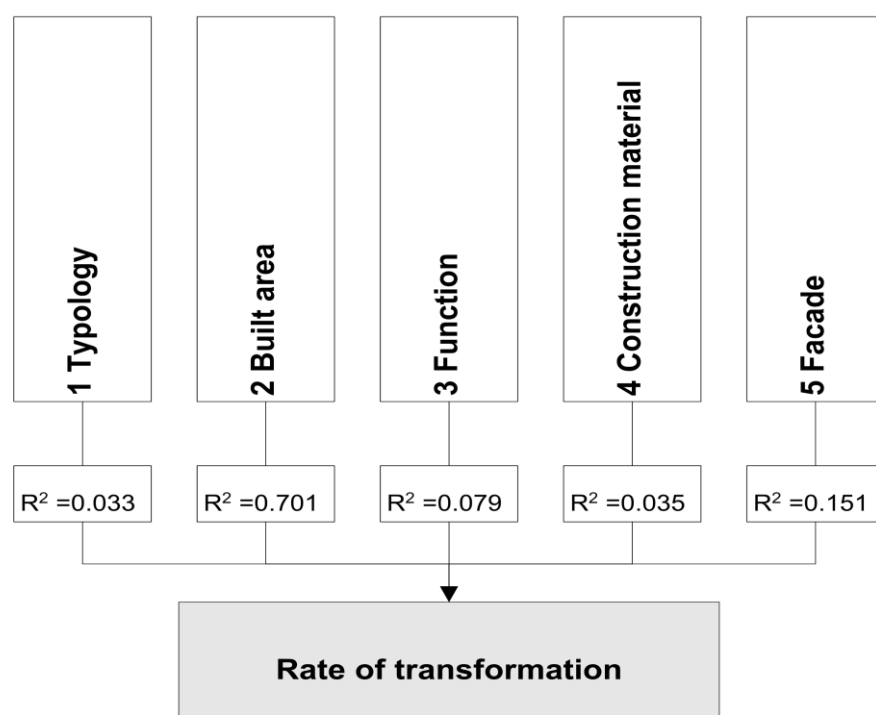


Figure 20: Analysis of the impacts of influencing factors on housing transformations

Although according to the reviewed literature tenure form might affect housing transformation, this study assumed that this impact should be negligible in Lar' s PEHs. This is because in Lar' s PEHs, majority of houses (94.7%) have the same tenure form which is freehold ownership. The conducted Pearson Product-Moment Coefficient test confirmed this assumption ($r = .013$, $n = 189$, and $p > .05$). Consequently, this study posited that housing transformations in Lar' s PEHs is independent of the tenure type.

The specifications of the original dwellings were detailed in Section 10 of the distributed questionnaire. The specifications covered 1) Location of PEHs, 2) Ratio of open and close spaces in PEHs, 3) Size of PEHs, 4) Spatial organisation in PEHs, 5) Ornamental elements in PEHs, 6) Façades of PEHs, 7) Construction material in PEHs, 8) Facilities of the house in PEHs, 9) Consistency between PEH and occupiers' life style, and 10) Differences between PEHs and vernacular houses. This study first evaluated the consistency among above factors. The conducted reliability test confirmed this consistency (Cronbach' s alpha

value=.721). Therefore, a new variable entitled post-earthquake housing specification has been formed by collapsing the 10 variables listed above. However, based on the results of the conducted Pearson Product-Moment Coefficient test, the study posited that the rate of transformations in PEHs is not determined by average quality of those houses ($r = .019$, $n = 189$, and $p > .05$).

With respect to the impacts of financial resources on the quality and quantity of PEH transformations, this study took two facts into account: 1) Lar' s PEHs were initially the only choices of the households; 2) there were various households with different wealth level that initially resided at the similar houses but not necessarily were going to live in the same conditions for ever. The assumption therefore was that the households will transform the houses up to the level that they could afford. The conducted Pearson Product-Moment Coefficient test confirmed that the rate of transformations in PEHs is significantly dependent on the wealth and income level of households ($r = .216$, $n = 188$, and $p < .05$).

All transformations in Lar' s PEHs were the result three indicators namely Consultancy services, Local labour, and Local Constructional materials (Alizadeh, 2003; Arsalan, 2007a). The conducted preliminary observations revealed that 98.8% of transformations were performed by householders, local workers, or local contractors. Therefore, this study intended to define a new variable entitled "low level facilities" which is a combination of Local labour and Local Constructional materials. Based on the results of the conducted Pearson Product-Moment Coefficient test it could be concluded that the rate of transformations in PEHs is significantly dependent on the availability of low level facilities ($r = .4453$, $n = 189$, and $p < .05$).

This study examined the impacts of infrastructures on Lar' s PEH transformations by investigating the influences of six factors: 1) Accessibility of commercial centres, 2) Usability of current roads, 3) Accessibility of public transportation system, 4) Accessibility of governmental offices, 5) Accessibility of public urban facilities, and 6) Accessibility to employment/work. The study combined all these factors of in order to form a new variable entitled "*Infrastructural Factors*". The conducted Pearson Product-Moment Coefficient test confirmed the rate of transformations in PEHs is significantly dependent on the accessibility of infrastructures ($r = .191$, $n = 189$, and $p < .05$).

2.4.6 Analysis and comparison of impacts of all influencing factors on Lar' s PEHs transformations

Figure 21 illustrates the impacts of all five major influencing factors on Lar' s PEHs transformations and their sub-factors on formation of housing transformations in Lar' s PEHs. The Figure reveals that 18.5% ($R^2=0.185$) and 2.1% ($R^2=0.021$) of model of PEH transformations are respectively determined by facilities of construction and Financial sources. However, the impact of infrastructural factors in forming the model of Lar' s PEH transformations is negligible. To conclude, out of these five factors, only three factors have significant impact on forming Lar' s PEHs transformations: 1) Household financial resources, 2) Accessibility of infrastructures, and 3) Accessibility of low-level facilities.

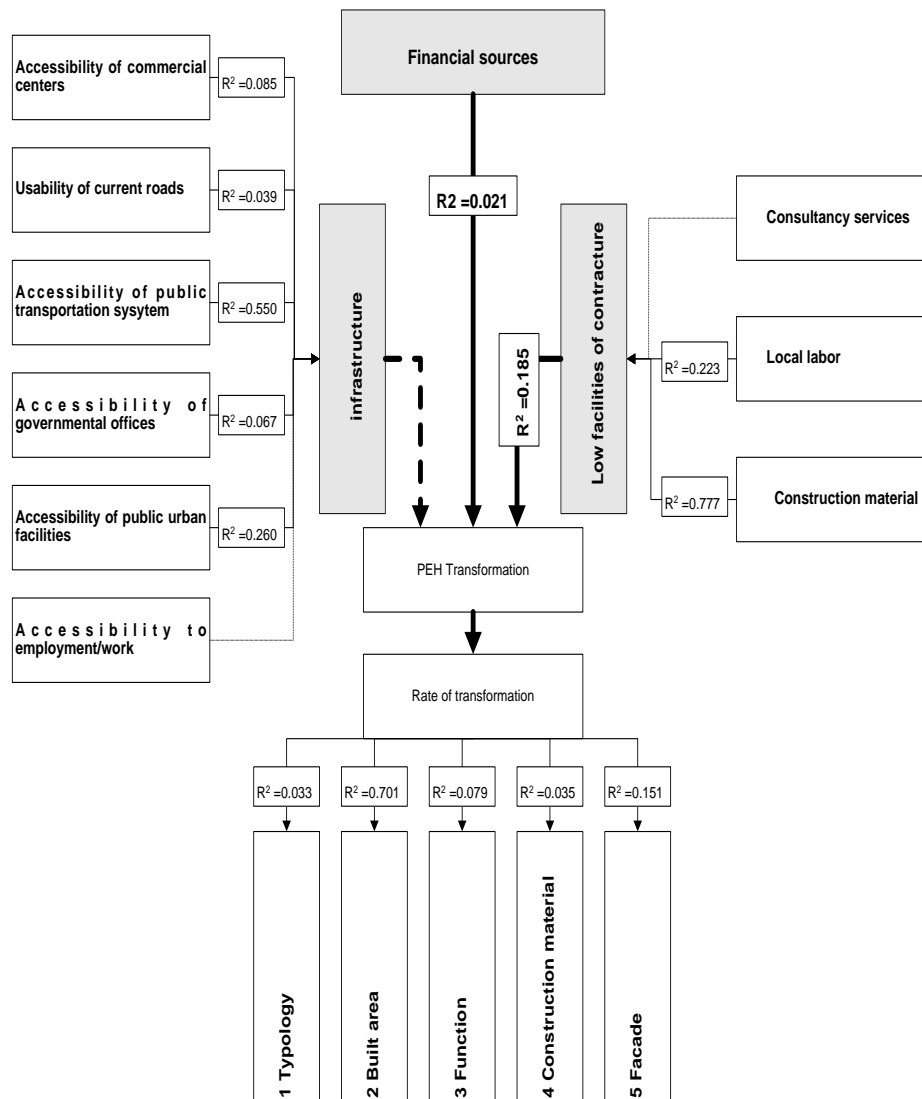


Figure 21: Impacts of all five influencing factors and their sub-factors on formation of housing transformations in Lar's post-earthquake houses

2.5 DISCUSSIONS

2.5.1 Discussions on people's motivations in transforming Post-earthquake houses in Lar

The strongest motivation for Lar's post-earthquake housing transformations was the willingness to adjust physical-living comfort conditions to most occupants. This is evident from this research that Lar's PEHs were uncomfortable. At the same time, the least important motivation was leveraging natural thermal comfort conditions. Initially, this fact might look somehow odd as Lar is located in arid zone of Iran. However, since currently people in Iran are being subsidised in terms of prices of electricity, they still have no attempt for replacing active thermal conditioning (air condition) systems (Figure 22) with passive techniques (e.g. wind catcher).



Figure 22: An instance for the applied electrical active air-conditioning system in Lar

2.5.2 Discussions on influencing factors on people' s motivations for transforming Lar' s PEHs

The conducted analysis in this study revealed that there is a positive significant relationship ($r = -.13$, $n = 189$, and $p < .05$) between the development of all transformational factors in Lar' s PEHs and people' s four major transformational motivations which target socio-cultural considerations, increasing income, growing household size, and rehabilitating the qualities of Lar' s traditional architecture. It could be concluded from this finding that changing housing specifications in PEHs will precede socio-cultural considerations. This could counter Alexander (1984) and Fallahi' s (2007b) idea that preparing urgent shelter for victims should be the main policy in PEH constructions. In other words, this study claims that since in a developing country like Iran PEHs are considered as semi-permanent residential units rather than mere temporary shelters, socio-cultural considerations must be taken into account just during the initial planning phase in order to prevent serious future problems.

Another important verified hypothesis in study explained the existing significant positive relationship between growth in household size and increase in motivation for PEH developments ($r = .243$, $n = 189$, and $p < .05$). Indeed, this finding verifies Habraken' s (1975) idea that any changes in household size definitely will be accompanied by changes in house size. On the other hand, Friedman (2002), when mentioning that the majority of housing developments are triggered by household size growths verified this idea. Parva and Dola (2007) categorised these types of issue into long-term and short-term developments. They ascertained that short-term developments of Lar' s PEHs are due to shortage of the living spaces in initial PEHs, whilst long-term developments follow the normal conditions of growth in household size. This idea also supports previous literature published in this field (e.g., Hojrup, 2003; Salam, 2006; Shiferaw, 1998).

The other verified hypothesis in this study described the existing significant relationship between spatial organisation in PEHs and socio-cultural motivations for transformations ($r = .238$, $n = 189$, and $p < .05$). This hypothesis was initially supported by Kashefy (1970) and Alizadeh (2003). They asserted that sudden changes in PEHs may precede many socio-cultural problems for the residents. It also verified Salam' s (2006) idea that those inconsistencies in pre and post-earthquake lifestyle may trigger motivations for transformations in PEHs. The verified hypothesis here reaffirmed all above theories, and also highlighted the importance of considering socio-cultural issues during PEH design phase.

Finally, the last verified hypothesis in this section explained the significant relationship between comprehensive changes in spatial organisation of PEHs and internments in motivations for transformations ($r = .238$, $n = 189$, and $p < .05$). This study interprets that this was due to people's tendency for following vernacular architecture of Lar which can be considered as an instance of socio-cultural issues.

Finally, it could be concluded that there are three groups of factors intensifying people's motivations for transforming PEHs in Lar. The first group which follows pre-earthquake architecture of Lar comprises of materials, built-up area, and spatial organisation between open and closed spaces. The second group which relates to post-earthquake housing specifications explains all shortcomings of PEHs as motivations of transformations. The explained shortcomings are as follows: materials, location of PEHs, and sizes of both land and built-up area. Finally, the third group relates the current prevalent architecture of Lar or neighbour cities which is considered as a motivation for changes in façades and materials.

2.5.3 Discussions the results of factor analysis for evaluating the impacts of each transformational motivation

Socio-cultural issues in developing PEHs are frequently supported by the published literature. For instance, Barakat (2003) asserted that rehabilitation of socio-cultural qualities should be taken into account in constructing and designing PEHs in the same degree of importance as for rehabilitation of the buildings. Besides, as supported by Comprehensive Plan of Lar (*Comprehensive Plan of Lar*, 2001) improvements in people's attachment to Lar's PEHs after transformation period is another instance of importance of socio-cultural issues. Therefore, this research studied specifications of both conditions of housing in Lar in order to trace the roots of the motivations for transformations. The results also showed that socio-cultural issues are so strong motivations for transforming PEHs. It revealed that more than 8% of transformational motivations is rooted on socio-cultural issues ($R^2 = .084$). This finding verified Kashefy's (1970) idea that socio-cultural issues triggered by inconsistencies between pre and PEHs led people towards transforming their PEHs.

On the other hand, the conducted factor analysis revealed that socio-cultural motivations and motivations for following traditional architecture of Lar follow the housing specifications of pre-earthquake houses in Lar. Moreover, among all mentioned motivations, two motivations namely "*adjusting relationship between open and close spaces in pre-earthquake houses* ($R^2 = 0.047$)" and "*re-applying ornamental elements of pre-earthquake houses* ($R^2 = 0.067$)" are the most important factors in determining the model of socio-cultural motivations. This finding supported Alizadeh's (2003) claim that spatial planning and ornamental elements of pre-earthquake houses play a big role in determining people's expectations of PEHs.

2.5.4 Transformational motivations and the applied changes in PEHs

Although people are not necessarily able to apply all the transformations that they desire, there could play a big role in determining the quality of housing transformations. Depending of the five verified hypotheses, this section discusses the impacts of transformational motivations on the quality of the transformations in PEHs.

First of all, it should be noted that the quality of transformations in houses are dependent on the occupiers' perceptions and preferences (Friedman, 2002). Based on the results of this study, every motivation could cause a different transformation in PEHs. The study also revealed that changes in typology, built-up area, constructional materials, and façades are mainly motivated by desire to copy prevalent housing forms. This finding verified Al-Naim (2008) and Shiferaw's (1998) idea.

Besides, the findings showed that converting function of PEH for improving income is accelerated by location of the houses. The results show that this type of motivation appears only when the houses are located besides the main roads. Moreover, the results of this study explained contrary influences of two motivations namely "*desire to copy prevalent housing forms*" and "*desire to follow traditional architecture of Lar*" on determining quality of constructional materials. In other words, the utilised materials in constructing initial PEHs are adjusted neither with traditional housing of Lar nor with the prevailing architecture of the region (*Comprehensive Plan of Lar*, 2001). Consequently, the occupiers try to convert the materials into either a traditional or a modern style that they are familiar with; however, as discussed earlier, the utilised alien material in construction of Lar's PEH caused some serious difficulties during housing transformations.

Façade transformations are often guided by the patterns of current prevailing architectural style of the region. However, according to the results of this study, façade changes in Lar were guided by the motivation to follow traditional architecture of Lar as well as motivation to model the prevalent housing style. This was an interesting finding that during early stages of post-earthquake housing, people are attached to their past memories from their previous lifestyle rather than widespread lifestyles of the time being. This paper asserts that this is because of historical value of architecture and culture in central parts of Iran. This finding which explains a socio-psychological aspect of living in PEHs has been ignored in the previous publications. Figure 23 summarises the motivations and the applied changes in post-earthquake housing transformation within the context of Lar.

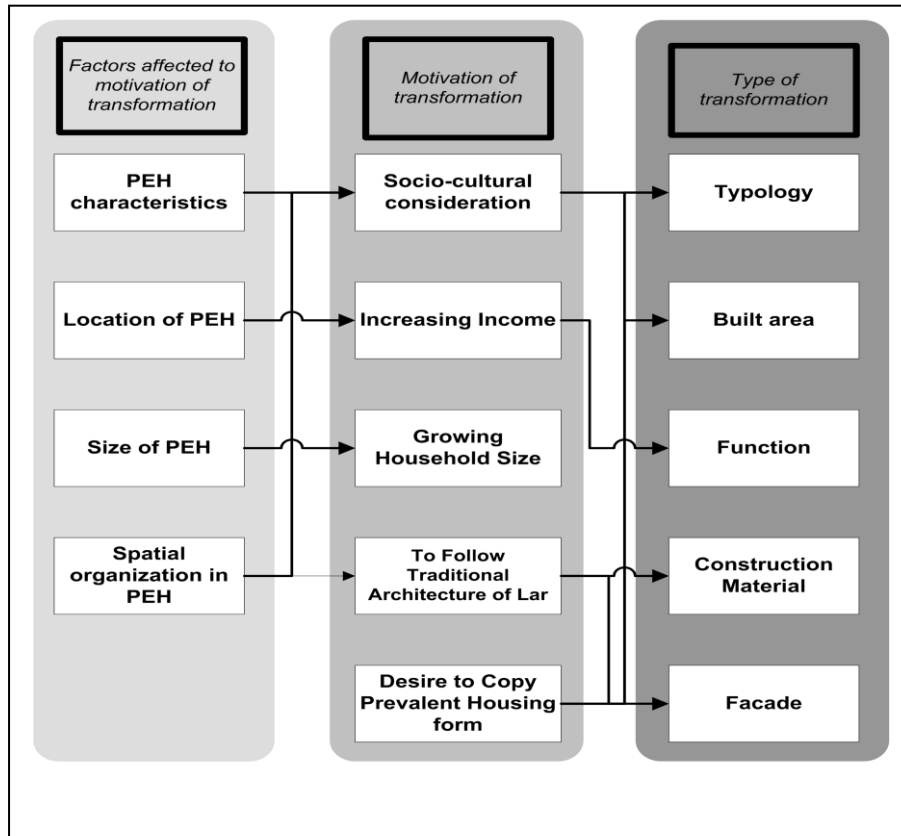


Figure 23: Motivations and the applied changes in post-earthquake housing transformation

2.5.5 Rate of transformations in Lar' s Post-earthquake houses and its influencing factors

Rate of transformations in PEHs is dependent of the changes in the architectural specifications of the PEHs. According to Shiferaw (1998), this rate of housing transformations in PEHs are dependent on five architectural factors including; morphology, built-up area, functions, construction material, and façades. The results of this study revealed that the most influencing factor in Lar' s post-earthquake housing transformations rate comprises of changes in built-up area which determine more than 70% of transformations ($R^2=0.701$). This finding supports Miromogtadaee' s (2009) earlier idea that transformations of Iranian houses are dependent on the changes in constructional materials and built-up area only.

2.5.6 Discussions on the impacts of each influencing factors on transformations of Lar' s Post-earthquake houses

The influencing factors on housing transformations are as follows: 1) Tenure form, 2) original dwelling (initial housing plan), 3) financial resources, 4) employable labor, and 5) the infrastructures. According to Shiferaw (Miromogtadaee, 2009), those factors could affect both quality and quantity of the transformations even though Dychtwald (Dychtwald & Shlomit, 2010) asserted that transformations are also dependent on people' s creativity in changing their houses. Nevertheless, according to Jha and Barenstein (Jha & Barenstein,

2010), there are some constraints by governments which may affect the transformations of PEHs. Following sections explain those mentioned factors in detail.

2.5.7 Influences of tenure form on transformations of PEHs in Lar

Although according to Shiferaw (Shiferaw, 1998) and Portnov and Odish (Portnov & Odish, 2006) tenure form have a significant impact on the quality of housing transformations, testing h6 in this study did not support the previous theories ($r = .013$, $n = 189$, and $p > .05$). In other words, the findings of this study did not provide any strong evidence for revealing the relationship between tenure forms and housing transformations in Lar' s PEHs. This paper interprets that this is because of the same tenure form of all PEHs in Lar that is freehold. Therefore, according to the results coming from the selected sample the transformations of Lar' s PEHs are independent from tenure forms of them.

2.5.8 Impacts of original dwelling (initial housing plan) on housing transformations

According to Tipple (Tipple, 1996) and Makachia (Macnair, 1994), transformations of PEH follow the specifications of the original dwellings. This is because of two reasons as follows: 1) limitations of the original dwelling which make the occupants change the conditions and 2) the influence of the specifications of the original dwelling on people' s decisions for transformations.

Concerning the limitations, since the original construction only covered a small part of the land, people were able to develop their houses in any way that they desired. On the other hand, sloped roof system of the original dwellings was a constraint to transform the PEHs, as it was not easy to integrate a new part with that type of construction. However, with regards to impacts of original dwelling on determining the quality of the transformations, since Lar' s initial PEHs were not acceptable in the beginning their architectural style have never been followed by people during latter transformations. As a result of all above discussions, failure in verification of h7 could be an acceptable finding ($r = .019$, $n = 189$, and $p > .05$) even though the hypothesis was initially supported by the previous publications (e.g., Baradan, 2008; Shiferaw, 1998).

2.5.9 The impacts of financial resources on post-earthquake housing transformation

According to Shiferaw (Shiferaw, 1998) and Dündar (Dündar, 2001), financial resources are very important factors in determining the quality of housing transformations. Although in Lar' s PEHs all initial financial funds have been provided by the government or NGOs, these were people' s capitals which facilitated the latter transformations. Therefore, in asserting H8 the initial assumption was that there is a significant relationship between household income and the level and quality of housing transformations. Indeed, the results supported this hypothesis ($r = .216$, $n = 188$, and $p < .05$). In other words, the results show how 84.7% of transformations happened from 1980 to 1990 when the economical conditions of the city suddenly improved due to people' s emerging trades with UAE' s merchants. Figure 24 and Figure 25 illustrate the differences between transformations of two PEHs belong to the families with different income range.



Figure 24: A transformed PEH belonging to household with monthly income lesser than USD400



Figure 25: A transformed PEH belonging to household with monthly income more than USD2300

2.5.10

2.5.11 Discussions on the impacts of available technical facilities and local labour on transformations of PEHs

According to Shiferaw (Shiferaw, 1998), employable labour is one of important factors determining the quality of transformations in PEHs. On the other hand, Friedman (Friedman, 2002) asserted that accessibility of technical services can improve adaptability of houses. Since transformations on Lar' s PEHs have been done by only consultancy services or local contractors, the results of this study show that transformations of Lar' s PEHs are independent from high-level engineering services. In other words, they only depend on availability of consultancy services or local contractors and on local constructional materials ($r = .4453$, $n = 189$, and $p < .05$). Therefore, use of those constructional materials and systems which are available and familiar for local workers and contractors should be taken into account in planning and design of PEHs. The conducted direct observations provided evidence for this claim when it highlights the problems of local workers with the unfamiliar constructional system of roofs applied in Lar' s PEHs (Figure 26 and Figure 27).



Figure 26: Workers are demolishing some parts of an original PEH due to heterogeneity of local materials and those applied in original PEHs



Figure 27: Difficulties in attaching new parts to the employed alien roof system in original PEHs

In conclusions, this section has two recommendations for improving latter transformations in PEHs: 1) employing some constructional systems during construction of initial PEHs that are understandable for local workers and 2) training local workers to be more familiar with the applied systems in constructing original PEHs.

2.6 The impacts of infrastructures on transformations of Lar's PEHs

Verification of h_{10} reveals the existing significant relationship between the quality of infrastructures and emergence of transformations ($r = .191$, $n = 189$, and $p < .05$). This confirms Shiferaw (Shiferaw, 1998) and Al-Naim's (Al-Naim, 2008) theory regarding the impacts of infrastructures on housing transformations. However, this research did not detect any evidence for effects of accessibility to employment/work on housing transformations of Lar. Nevertheless, previous works recognised this (e.g., Al-Naim, 2008; Shiferaw, 1998) as a highly influencing factor for determining the qualities of housing transformations. One of the reasons could be due to lack of formal employments in New-City of Lar and most of the people still go to the old-town to work. Therefore, the condition is the same for all people and not influencing the process significantly. In conclusions, the study proposes providing higher level of infrastructure than the need of the time being in development of similar PEHs.

2.6.1 Discussions on the results of analysing influencing factors on post-earthquake housing transformations

This study explained the existing logical relationship between three influencing factors on the quality of post-earthquake housing transformations, namely infrastructure, local labour and contractor, and financial resources. These are three factors which determine the level of housing transformations. Nevertheless, based on what discussed in this paper, original dwelling and tenure form are two factors which are not significantly affecting housing transformations in Iran even though their importance has been highlighted in previous researches. In other words, the findings of this study show that expediting transformations in Iranian PEHs is dependent on availability of infrastructures, funds, and finally professional and non-professional workers. Table 6 explains above mentioned factors and their recourses. According to this table transformation in PEHs is a process which starts concurrently with initial planning for those houses and lasts for a long time during occupancy period. In other word, financial sources influences on long-term after occupancy and availability of infrastructure influences on short-term after occupancy.

Table 6: Influencing factors on transformation of PEHs and their resources

Factor	Facilitated by	Time to be effective
Availability of Financial resources	Occupiers	In long-term during occupancy period
Availability of Professional and non-professional workers	Training programs conducted by government	After finishing reconstructions

Availability of Infrastructures	Governmental sectors who are in charge of reconstructions	As soon as starting for the occupancy
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2.7 CONCLUSION

Reconstructed post-earthquake shelters in Iran are usually not suitable due to the limited time and funds. In addition, victims (or residents) usually need to transform initial temporary shelters in order to use them for permanent occupancy purposes. This study introduced new approaches for increasing housing transformability in PEHs in Iran. This study looked at housing transformation as a result of collaboration among government, designers, and occupants. The study posits that leveraging transformability in PEHs could promote temporary houses into permanent homes in post-earthquake area. In other words, the results of this study could contribute towards creating some post-earthquake housing reconstruction policies, which could help the society achieve the following four main objectives:

- To enable occupants to modify PEHs based on their requirements and needs
- To reduce PEHs reconstruction expenditure by designing PEHs for a long-term occupancy so that they are not demolished after occupancy
- To provide the PEH residents with a high quality living area
- To enable the residents for adapting their PEHs based on the changes in household structures.

This study proposes that the above objectives must be achieved through three phases: Pre-earthquake phase, Reconstruction phase and Post-occupancy phase.

Pre-earthquake phase: (for new houses to be built in high-risk earthquake area)

- Study of vernacular architecture in high-risk earthquake area
- Understanding the household's idea about their house in high-risk earthquake area.

Reconstruction phase :(PEHs)

- The design should consider the vernacular architecture in post-earthquake area
- The design should consider the original dwelling (initial housing plan) and can be transformed

- The planning of infrastructure of post-earthquake area should be the ability of initial housing extension

Post-occupancy phase :(for new houses to be built in high-risk earthquake area)

- The municipality should provide law and regulation for transformation of PEHs. (based on defending initial house)
- Training of local labours and contractors for housing transformation
- Occupancy should transform (renovate) their PEHs based on municipalities' regulation.

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3 Challenges for Implementing Liveable Communities in Bangsar, Kuala Lumpur

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Abstract: Liveability refers to the health and social quality of an area as perceived by all stakeholders in study area. Bangsar is a residential area which comprised of different level of social classes. Therefore liveability level in Bangsar communities also varies due to its existing condition of public realm in different areas and diversity group of people. Hence implementation of liveable communities in Bangsar is not achievable as a whole. Every community in Bangsar has its own common barrier for implementing liveable communities. Therefore there is a need to examine existing community liveability and common barrier for achieving desired level of liveability in Bangsar. The important key elements in liveable community such as physical structures, natural features and service provisions are examined to understand what constitute a liveable community. The urban morphology and survey research method are used to identify and evaluate the liveability in Bangsar's community. It is carried out to examine the challenges for creating liveable communities and real needs of the residents towards liveable community in Bangsar. The outcome of this study is potential to use as a resource that can assist the urban planning industry in Kuala Lumpur to incorporate health and social outcome in new proposed development.

Keywords: Liveability, Liveable Communities, Physical Structures, Natural Features, Service Provision

3.1 INTRODUCTION

Bangsar is an affluent residential suburb on the outskirts of Kuala Lumpur with clusters of low and high cost residential areas. The earliest settlement in Bangsar was formed by rubber estate workers and railway workers living along Kuala Lumpur to Klang railway track and rubber estate workers. The residential areas along Jalan Kurau, Jalan Tenggiri and Jalan Sepat are believed to be the earliest housing development in Bangsar. Nowadays Bangsar grew to include young Malays, Chinese, Indians professionals and expatriates. Community liveability is a global hot topic to be discussed nowadays and used to evaluate the general health and social wellbeing of communities within an area. It directly influences people who live, work or visit the area. Various influencing factors in developing a liveable and healthy community are explored to identify the issues and approaches for sustaining the wellbeing in Bangsar community.

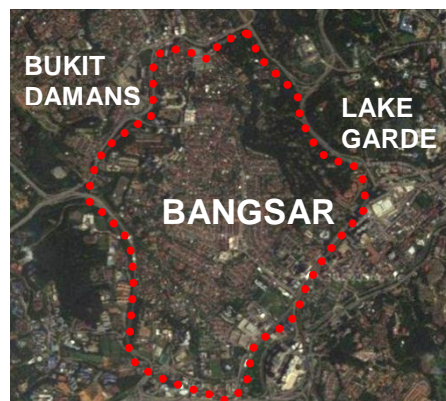


Figure 1: Location of Bangsar (Source: <http://maps.google.com.my>)

Community liveability in Bangsar is affected by its existing condition in public realm which includes public facilities, transportation, land use zoning and opportunity for recreation. Every community in Bangsar has its own common barrier for implementing liveable community. Bangsar comprised of communities with different level of liveability within pockets of residential area. Therefore implementation of liveable communities in Bangsar is not holistically achievable. A community with higher liveability is an area believed to improve public health and safety resulting in an increase in property value and social activities. A liveable community should promote human health and wellbeing through development of environments that provide social, economic and environmental benefits.

The main aim of this study is to examine the reason why Bangsar failed in implementing liveable communities as a whole. This study also focus on the challenges for creating liveable communities in Bangsar and what constitute a liveable community. Key elements and principles in liveable communities need to be studied in order to understand the frameworks and guidelines for evaluation on the liveability in Bangsar's communities. The common barriers that Bangsar's communities confront to create a liveable community are also examined.

3.2 LITERATURE REVIEW

Liveability is most often used to describe the diverse aspects of society, surroundings, and shared experiences that shape a community (Elizabeth L.S, 2012). The various factors to improve a community' s quality of life and wellbeing include the built and natural environments, economic prosperity, social stability and equity, educational opportunity, and cultural, entertainment and recreation possibilities. (Elizabeth L.S, 2012). However, the subjective nature of quality of life and wellbeing of people adds to the imprecision of a definition for liveability. Moreover, every community circumstances and resident profile in certain area are unique; therefore the definitions of liveability vary due to different responses of community members.

A liveable community that recognizes its own unique identity and places a high value on the planning processes that help manage growth and change to maintain and enhance its community character (Diane G, 2005). In the research of "*Building Liveable Communities in the Lower Hunter Region*" by Wells V. et al. (2007), she identified four key elements of liveable community for example physical structures, natural features, service provision and social principles. In a healthy and liveable communalities or neighbourhood, the natural environment contributes to our sense of place, sense of community, and feeling of attachment or belonging, all of which are health promoting and each impacts on people' s health, enjoyment and general wellbeing (Wells V. et al., 2007). This shows that positive health impacts of the natural environment which highlights its importance of creating neighbourhoods or communities that are both healthy and liveable for the people within.

3.3 RESEARCH METHODOLOGY

The study site will focus on the residential area and public spaces in Bangsar Utama as refer to figure 2.. There are five elements in liveable communities to be measured to identify the liveability in the studied area, such as public space with community facilities, pedestrian and bicycle paths, green open spaces, public transportation and medical services. Different research methods are used to identify and measure the availability of different key element in liveable communities for the studied area.

Urban morphology method is used to identify the location of activity spots, and availability, connection and distance of public space, pedestrian and bicycle paths, green open spaces, public transit and local basic services (health and education) from the residential area. The mapping study is carried out to indicate the location of the studied elements and its accessibility for people in Bangsar Utama. In addition, **observation** is part of this research methodology for collecting the data such as the physical characteristic and existing condition of public space with community recreational facilities, pedestrian and bicycle paths, green open spaces, public transit station, recreation sites and local basic services in the studied area. It is also tend to observe and understand the relationship of the built environment with behaviour of people and how people use of the facilities or spaces provided. Furthermore, the common barrier for implementing liveable communities is also need to be observed and recorded in this method.

Survey method is carry out to understand the efficiency and existing condition of public spaces with facilities, pedestrian paths, green open spaces, public transit, medical services in the perspective of residents in the studied area. The survey is conducted by questionnaires on the target groups who are residents at Bangsar Utama and Bukit Bangsar. This method is also leading to understand the real need of the residents in their living environments for creating a liveable community.

The two types of research methodologies which are urban morphology and survey methods are only implemented and focused in high rise flats of *Keretapi Tanah Melayu Berhad* (KTMB) and Sri Pahang), public spaces and commercial area at Bangsar Utama. Flat Sri Pahang residential area is comprised of 3 blocks of flats with 16 storeys each at Bukit Bangsar whereas Pangsapuri KTMB is comprised of 3 blocks of flats with 14 storey each at Bangsar Utama. Malays make up the majority of the population and minority of the population are India. The key elements in liveable communities that are needed investigate for evaluating liveability of particularly at Bangsar Utama. The target groups for survey are residents in high rise flats.



Figure 2: Study site- Flat Sri Pahang and Pangsapuri KTMB. (Source: google map)

3.3.1 Data Collection

Data collection is carried out through two procedures. Firstly, the land use zoning and the location of public spaces with facilities, green open spaces, pedestrian and bicycle paths, public transportation and local basic services (school and health) are identify in mapping study. The linkages and distance between housing to that studied common spaces are also

carry out in the mapping study. Existing condition and other findings on studied elements in research site are needed to be observe and record.

Secondly, data collection was through survey method by questionnaire applied on the respondents at Bangsar Utama. The spot areas for conducting this survey will be focus at residential area such as KTMB flat and Sri Pahang flat, commercial area such as restaurants and grocery stores, and public transit station. The respondents who are participate in this survey method are select randomly regardless of age, gender, race and others to ensure equal chance of being selected.

3.4 RESULTS AND DISCUSSION

Due to general observation and mapping study, every liveability indicators that are studied to investigate liveability in study site have its own barrier for achieving desired liveability level for the communities. In addition, the studied key elements in liveable communities are mutually support each other for achieving level of liveability in study site. For example, public transportation system in Bangsar Utama is generally meet the resident's need and the transit stations are located within walking distance from flats, however it's accessibility are affected by the poor condition of pedestrian paths.

Furthermore, the provision of green open spaces are being restricted by the compact developments of residential blocks and become a forgotten issues while earliest stage of housing planning for both flats. Low quality of walking environments especially surrounding flats area are definitely decrease the liveability level of the communities. The residents are seemed to be accustomed to the community recreational facilities that should be under maintenance and improvement. They are being adapted to the suboptimal and unsafe conditions of the community recreational facilities and pedestrian paths that are available in their neighbourhood area. The built environments are significantly affected the residents' behaviour and the growth pattern of daily activities based on general observation on site.





Figure 3: Poor condition of pedestrian paths in Bangsar Utama



Figure 6: Outdoor recreation spaces with concrete flooring

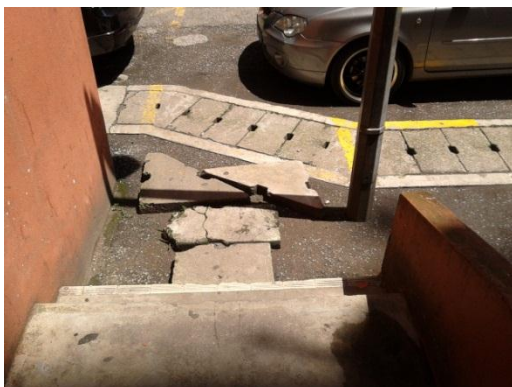


Figure 7: Lack of maintenance on the pavement and refuse area



Figure 8: Poor condition of badminton court in KTMB Fla

The survey revealed that different studied elements as liveability indicators for evaluation on the liveability of communities in study site are inconsistent in performance due to results. Respondents generally noted community recreational facilities as the most important elements of a liveable community. However, the provision of community recreational facilities in both flats is insufficient to cater for the size of population. Therefore it failed to enhance liveability of the communities in study site. Hence the survey on the importance level of community recreational facilities as rated by the residents can be act as reference while addressing issues of shortcoming on it.

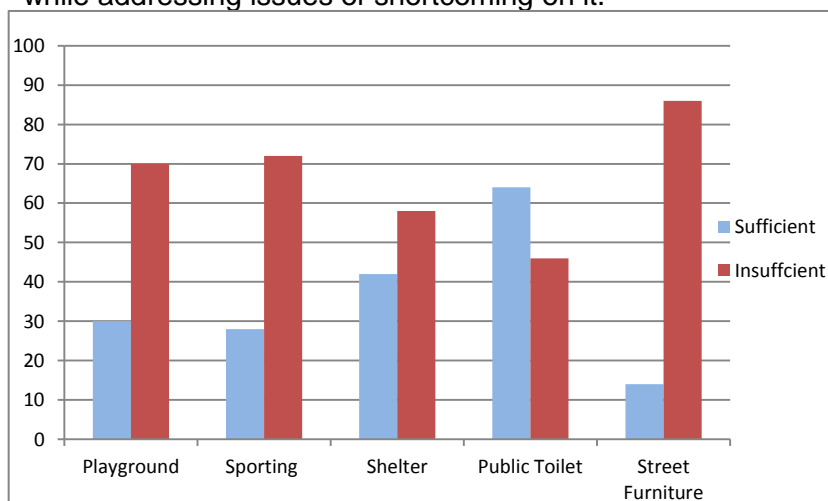
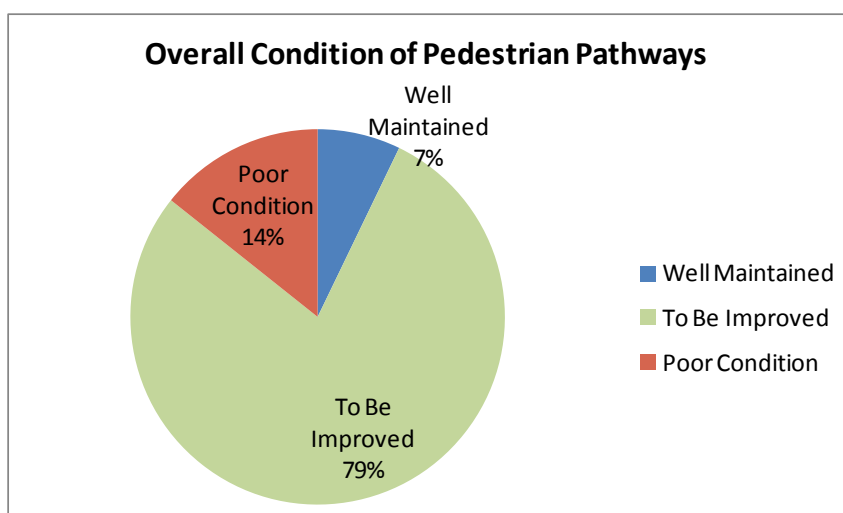


Chart 1: Sufficiency on provision of community recreational facilities.

In addition, the findings from the survey on existing pedestrian paths reflected that it is pedestrian unfriendly due to its poor connectivity and failed to encourage people to walk to their destination. Existing pedestrian paths are one of the common barrier for implementing liveable communities and health promoting activities since the path's condition made the walking environment more uncomfortable and treacherous over time. Overall condition of pedestrian paths needs to be improved to create a pleasant and safe for the residents.



Green open spaces are also insufficient to cater for residents' need in participating outdoor recreational activities for promoting healthy lifestyle. Similarly for existing pedestrian paths, it's shortcomings are need to be take into account to achieve the desired level of liveability as perceived by the residents. Elements which are important in improving the existing condition of green open spaces can be carried out in accordance with resident's needs and expectation.

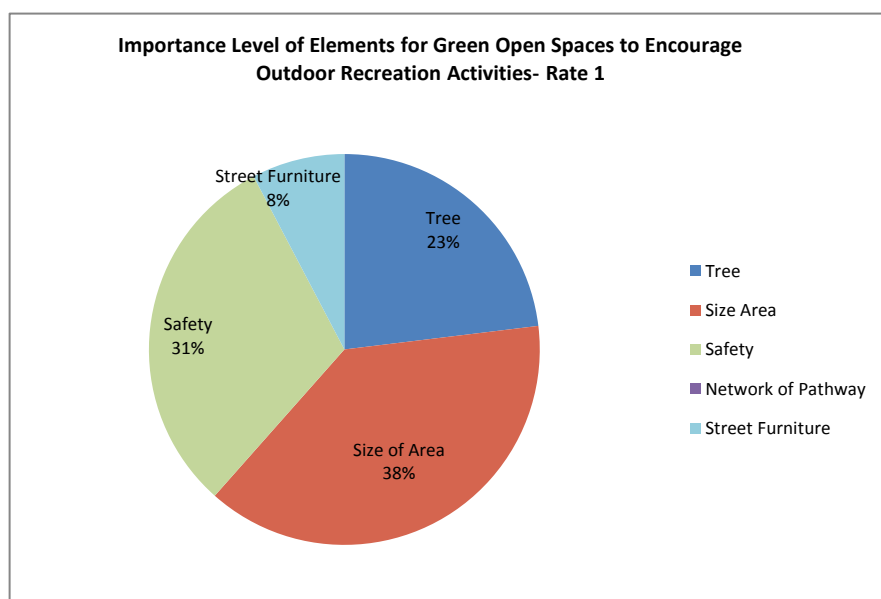


Chart 3: Importance level of elements for green open spaces to encourage outdoor recreation activities- Rate 1.

In general, the residents in study site are public transport dependent group and satisfied with the services provided by public transport system in Bangsar Utama. This revealed that public transportations are successfully playing its role in creating liveable communities in Bangsar Utama by supporting the resident's daily activities. Medical services are also an key role for implementing liveable communities and promoting public health. There is lack of government medical services at Bangsar Utama but efficiency of Light Trail Train (LRT) provides another alternative solution on it therefore the residents are willing to travel to Kerinchi area obtain medical care in Kerinchi One Malaysia Clinic. Furthermore, the evolution of private medical services in Bangsar Utama has not been a direct path of increased generosity toward the communities in both flats.

Followings are the summary of the results extracted from the conducted survey.

Scale of level of importance

1	Less important
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2	Slightly important
3	Important
4	Fairly important
5	Very Important

A. KEY ELEMENTS IN LIVEABLE COMMUNITIES

Importance level in creating liveable communities	Elements
1	Community Facilities (playground, sport facilities, shelter, public toilet and street furniture)
2	Green open spaces
3	Public transportation
4	Medical services
5	Pedestrian paths

B. PUBLIC SPACES WITH COMMUNITY FACILITIES

	Insufficient	Sufficient
Sufficiency on provision	•	
	Disagree	Agree
Easy accessibility		•
	Disappointed	Satisfied
Satisfaction level		•

Importance level of community recreational facilities in public spaces	Elements
1	Playground
2	Sport facilities
3	Public toilets
4	Shelter
5	Street furniture

C. PEDESTRIAN PATHS

	Disagree	Neutral	Agree
It is important for provide alternative transportation option instead of automobiles.			•
Encourage residents to walk.	•		
Well connected to activity spots	•		
	Poor condition	To be improved	Well Maintained
Overall condition		•	

Importance level of elements along pedestrian paths	Elements
1	Covered by roof
2	Street lighting
3	Disabled access
4	Tree
5	Barrier from road

6	Zebra crossing
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D. GREEN OPEN SPACES

GREEN OPEN SPACES			
	Insufficient		Sufficient
Sufficiency on provision	•		
	Disagree	Neutral	Agree
Encourage residents to participate outdoor recreation activities	•		
Easy accessibility		•	

Importance level of elements for green open spaces to encourage outdoor	Elements
1	Size of area
2	Safety
3	Tree
4	Street furniture
5	Network of paths

E. PUBLIC TRANSPORTATION

PUBLIC TRANSPORTATION				
		Yes	No	
Use of public transport		•		
		Bus	LRT	
Type of public transport		•		
			Prefer own vehicle	Poor coverage of transit route
				Infrequency of transit
Reasons not using public transport		•		

	Disagree	Neutral	Agree
Operate on time			•
Easy accessibility			•
Feel safe and relax when using			•

F. MEDICAL SERVICES

MEDICINE SERVICES			
	Yes	No	
Use of government health clinic in Bangsar Utama		•	
	Kerinci One Malaysia Clinic	Hospital	Others
Reasons not using public transport	•		

	Disagree	Neutral	Agree
Afford to pay the cost on private medical services	•		
Easy accessibility			•
Satisfaction level		•	

3.5 CONCLUSION AND RECOMMENDATIONS

Community liveability is an important issue which is related to health and social wellbeing in the community. Everyone wants to live in a liveability community and it is significantly shaped by the built environment and social quality of an area. Healthy and liveable communities improve the welfare and well-being of people by expanding the quality of key elements in living environment such as transportation, housing, medical services, public facilities and natural resources.

Based on results from both data collection, the residents are accustomed and adapted to the suboptimal conditions of the existing facilities and services on study site such as green open spaces, pedestrian paths and community facilities. In fact the poor condition of its built environment are significantly influenced the growth pattern of resident's daily activities. Poor in green open spaces, pedestrian paths and community recreational facilities at study site decrease the quality of life and thus diminish the liveability level of the communities.

People will walk more when the paths are connected to destination. Therefore it is crucial in enhancing the design of the pedestrian paths in order to ensure continuity of walking routes. Materials or finishes used on the paths should consider pedestrians safety during their walk. The location of paths have to be enhanced by establishing the shortest route and linkage between residential and activity spots areas to enable residents to walk between them. Moreover, the access to public transport needs to be enhanced to assist residents to meet the minimum requirement for physical activity. Use of green open spaces is crucial to increase the interaction between residents thus slow down residents from hectic pace of urban life. Safety in green open spaces is also needed to be taking into consideration while providing a good quality of natural environment for residents.

The quality of neighbourhood aesthetic and social wellbeing of residents is encouraged by providing adequate amount of community recreational facilities for a range of uses and different ages of population. Quantity of community facilities and size of area of public spaces with community recreational facilities have to be proportionate with the size of population in the area to avoid insufficiency and decrease in resident's recreational opportunities and social engagement. In addition, disparities and limited access to health service need to be avoided since it negatively affects resident's quality of life. Barriers to medical services such as high cost and lack of insurance coverage are needed to take into account while improving public health.

This paper is potentials to use as a resource that can assist the urban planning industry in Kuala Lumpur to incorporate health and social outcome in proposed development. It is also can be acts as a guide for local government and health professionals interested in assessing the liveability of community in new proposed development. Improving community liveability in urban area is an important concern for governments and private sectors nowadays. Hence it is important to carry out opportunity of being able to deliver positive health and social wellbeing outcome to the community.

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4 Current Sustainable Development Practices in the Malaysian Construction Industry: Stakeholders' Perspective

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Abstract: Economically, Malaysia has one of the fastest growing construction industries in the world; however, the necessary balance between socio-economic and ecological systems – to avoid further environmental damage – has not yet been reached by the industry. The aim of this paper is to explore the extent of sustainable development practices (socially, environmentally and economically) in the Malaysian construction industry. These views were explored through in-depth interviews with thirty stakeholders from various backgrounds of the Malaysian construction industry. The study finds that economic issues have always been the first priorities among stakeholders in any decision-makings for building projects. As such, cost becomes one of the major reasons for the slow progress in implementing environmental-friendly practices in building projects. Socially, there is still a wide gap of knowledge and awareness on sustainability issues among stakeholders, explaining the lack of commitment in achieving social sustainability. For example, post-occupancy evaluation and universal design are far from being 'mainstream' practices within the construction and property sectors. These are some of the findings that highlight the issues to be bridged in practice as well as in any sustainability assessment framework, in order to make sustainability more socially acceptable and integral in the local construction industry.

Keywords: Sustainable Development, Sustainable Building Practices, Construction Industry, Building Stakeholders, Qualitative Research, Malaysia.

4.1 INTRODUCTION

Malaysia has one of the fastest growing construction industries in the world (Australian Business Council for Sustainable Energy [ABCSE], 2007) and currently categorised as a “newly industrialised country” (Mankiw, 2008), indicating its success economically. However, the industry's emphasis on providing buildings with the best possible (lowest) cost has taken its toll on certain environmental and social issues in the country. The exploitation of resources, uncontrolled, and improperly planned development has resulted in the deterioration of the environment for decades such as land pollution due to uncontrolled solid wastes disposal, as well as soil erosion and silting of water course, which in turn causes water pollution, flooding in low-lying areas and flash floods in urban areas (Aiken, *et al.*, 1982; Begum, *et al.*, 2006; Department of Environment Malaysia, 1997; Economic Planning Unit of Malaysia, 2005; Sani, 1999). On top of this, the industry's reliance on foreign labour has resulted in low level of productivity and quality (Chan, 2009; CIDB Malaysia, 2007), as well as higher rate of work-related accidents (Abdul-Aziz, 2001; Chan, 2009; CIDB Malaysia, 2005).

These predicaments reflect the imbalance between environmental and socio-economic development; thus the benefits of development may be negated by the costs of environmental and social impacts. If this is the case, then the current Malaysian construction and building practices can be deemed as not sustainable. The adoption of sustainable development (i.e. balancing economic development with environmental protection and social development) in Malaysian construction industry is therefore very timely and crucial.

This paper aims to explore the extent of sustainable development practices (socially, environmentally and economically) in the Malaysian construction industry to define gaps that need to be bridged to promote sustainable building development in Malaysia. The paper first outlines the method used in the research. Then the extent of economic, environmental and social practices as described by the stakeholders are explained and discussed.

4.2 METHODOLOGY

It was anticipated that different stakeholder groups would have different views about different challenges and motivations for pursuing sustainable outcomes. To capture these different views, the research was conducted through in-depth interviews. Patton (2002, p.348) states that “the purpose of qualitative interviewing is to capture how those being interviewed view their world, to learn their terminology and judgments, and to capture the complexities of their individual perceptions and experiences.” The interviews used semi-structured, open-ended questions to allow the respondents more freedom and creativity to respond to the questions. A semi-structured approach provides reasonably standard data across participants but also allowed flexibility to probe answers more deeply and gather more information than is found in structured interview (Minichiello, *et al.*, 2008). The results were then analysed to define gaps that need to be bridged to promote sustainable building development in Malaysia.

A total of 50 commercial building stakeholders currently practicing in Kuala Lumpur, Selangor and Putrajaya were purposely selected as participants and sent an invitation email, with 30 stakeholders agreed to be interviewed consisting of 12 consultants, 5 developers/owners, 3 builders, 4 facility managers, and 6 regulators/policy makers. The interviews were conducted from early January to early March 2009. Table 1 is a summary of the profiles of the interviewees.

Building-owners group of stakeholders are those who work in an organisation that owns at least an energy-efficient purpose-built office building. Other groups of stakeholders however, were not particularly chosen based on their knowledge of, and experience in, sustainable or green building. This approach allows a comparison of views between the two groups of sample with different background to be made. The purposive sampling, particularly judgement sampling, was used to provide the means to investigate a specialised population of stakeholders who have experienced in the relevant field for more than ten years. A sample size of 20 to 30 is deemed adequate to enable internal generalisation in a qualitative study (Leech, 2005).

Acronyms:

PAM = Persatuan Arkitek Malaysia / Malaysian Institute of Architects

ASHRAE = American Society of Heating, Refrigerating & Air-Conditioning Engineers

MACRA = Malaysian Air-Conditioning & Refrigeration Association

ACEM = Association of Consulting Engineers Malaysia

Table 1: Summary of Interviewees (N=30)

Position of Interviewees	Type of company/organisation	N
Private Sector		23
<i>Consultants:</i>		
Architect & former President of PAM	Architectural consultant	1
Architect & Deputy President of PAM	Architectural consultant	1
Architect & Vice President of PAM	Architectural consultant	1
Architects	Architectural consultant	6
Managing Director & former President of ASHRAE Malaysia Chapter & MACRA	Engineering consultant and trading	1
Managing Director & former President of ASHRAE Malaysia Chapter & ACEM	Engineering consultant	1
Mechanical Engineer & Director	Building environmental consultant	1
<i>Developers / Building owners:</i>		
Head of Property Management	Major real estate developer and investor	1
Project Coordination Manager	Major real estate developer and investor	1
Executive Director & Head of Corporate Investment	Major real estate developer and investor	1
Senior General Manager	Major real estate developer and investor	1
Project Director	Bank / Building Owner	1
<i>Builders:</i>		
Managing Director	Major property contractor	1
Executive Director	Major property contractor	1
General Manager	Major property contractor	1
<i>Facility managers / Building operators:</i>		
Property Maintenance Manager	Major real estate developer and investor	1
Chief Executive Officer & former President of ASHRAE Malaysia Chapter	Facility management	1
Operation Manager	Property management	1
Public Sector		7
<i>Facility managers / Building operators:</i>		
Principal Assistant Secretary	Ministry of Energy, Water & Communications	1
Assistant Director & former President of ASHRAE Malaysia Chapter	Independent, non-profit making research organisation	1
<i>Government Projects Implementer:</i>		
Branch Director	Public Works Department	1
<i>Policy makers / Regulators:</i>		
Principal Assistant Director (Urban Design)	Statutory Body under Ministry of Federal Territories	1
Senior Architect	Local Authority under Ministry of Federal Territories	1
Senior Manager	Statutory Body under Ministry of Works	1
Senior Technical Advisor	Statutory Body under Ministry of Energy, Water & Communications	1
Total		30

4.3 RESULTS AND DISCUSSIONS

Interviewees' responses can be grouped into current economic, environmental and social practices. Even though findings are grouped and discussed separately under these three issues, many aspects are interrelated; hence, cross-references are made whenever necessary.

4.3.1 *Current Economic Practices*

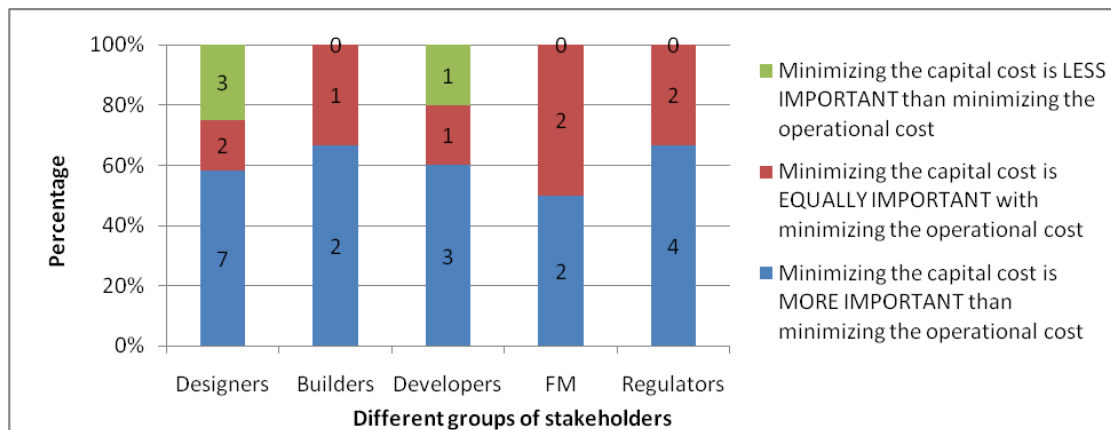
4.3.1.1 *Have economic issues been the stakeholders' first priorities?*

Majority of the interviewees (77%) believed that they had always considered economic issues as the first priorities in any decision-makings for office building projects. It is also worth noting that the remaining 23% of stakeholders who did not consider economic issues as first priorities did not include developers. The most common economic issues cited was the economic return especially when the projects involved clients who build to sell. For owner-occupied buildings, "Corporate Social Responsibility" was cited as the driving factor in decision makings apart from economic considerations (BEnvCon/Male/1). For most local developers and building owners however, PMaker/Male/5 believed that they only concerned about having their buildings meeting the minimum mandatory standards enforced by the approving authorities and built at minimum cost without giving so much thought about energy efficiency concept as it was considered an economic waste due to heavily subsidised electricity tariffs. Nevertheless, he added that the situation has slowly started to change. For others who believed economic issues were not their first priorities cited "health and well-being of building users" and "deliver on time and in good quality" instead. Only one interviewee cited that economic issue is "equally important as environmental and social issues" (Arch/Male/5).

4.3.1.2 *Capital cost, operational cost or both? Would sustainability guarantee higher market value?*

Majority (60% or 18) of the interviewees, consisting of all stakeholders groups, had always regarded minimising the initial capital cost as more important than the long-term operational costs (see Figure 1). These stakeholders admitted that generally the local building industry is less concerned about the operational and maintenance costs as these costs are perceived to be the tenants' problem. In cases where unawareness and unwillingness were not an issue, developers admitted that they were improperly and inadequately advised by consultants to consider both initial and future costs and benefits (savings) of an investment to facilitate the effective choice between different building alternatives or to select more competitive technologies. For example, "Lots of consultants neglect life cycle costing and do not have the knowledge to execute life cycle cost analysis" (Arch/Male/8. Negligence in life cycle costing was also relevant to local builders.

Only 13% (or 4 out of 30) support the importance of minimising the long-term operational costs. They believed that this consideration is important in two circumstances. First is when the project is to be rented/leased and managed by the client (speculative developer or owner-occupier). According to Bordass (2000), although speculative developers are always interested in saving money, capital cost is not always the biggest thing. What counts is the return on investment, which means maximising lettable area and rental value; and minimising time to completion and occupancy (Bordass, 2000). Conversely, a few interviewees believed that office spaces that are built to be sold by clients among speculative developers rarely reflect the consideration of operational costs because in any case, the developers do not pay the fuel bills.



Figure

1: Frequency distribution of interviewees with different priorities between capital and operational costs (N = 30)

Second is when developers/owners are absolutely certain that their property market/rental values would be much higher in the future. Unfortunately, all six developers/building-owners interviewed perceived that there has been no relationship between sustainability and property market values in the Malaysian context, due to two reasons: 1) lack of local empirical data to prove the economic benefits of green or sustainable buildings to local investor; and 2) lack of awareness amongst market participants about the benefits of sustainable design in general. Therefore, it is unsurprising that this lack of demand on green building has resulted in an absence of green criteria on value component when undertaking a valuation of a commercial office building. Assimakopoulus *et al.* (2003) pointed out that valuation professionals require investor or client specific inputs for the calculation of worth. If these inputs do not comprise the client's wish to take advantage of the benefits of sustainable buildings, then property professionals will have no basis for including sustainability issues into their estimates of market value. Hence, it is sensible to suggest that at present, the local market has not yet accounted for property characteristics which add values to the user and the environment. This phenomenon is confirmed by Rahman (2011) who recently noted, in Malaysia, "the difference in rental rates between green and non-green buildings is not so much due to the green features, but more on supply and demand factors within the specific location."

4.3.2 Current Environmental Practices

4.3.2.1 What are the stakeholders' perceptions on the recently built office buildings?

Interviewees were asked to make some general comments on office buildings being built in Malaysian cities since five years ago (2005-2009). Altogether, there are 44 comments made and these are grouped into 13 categories as shown in Figure 2. Generally, the comments touch issues related to the environment, social and/or economy; however, the negative comments outnumbered the positive ones.

The results clearly shows that most commonly cited responses (25%) are about "Building envelope" cited by all stakeholder groups with the exception of facility managers; however, only one out of ten comments is encouraging. For example, one interviewee from a local authority (Regr-PMaker/Female/3) suggested that office buildings built since five years ago are 'greener' in their architectural design than those built prior to that period. However, this view contradicts those given by most of the interviewees from the private sector. Among the comments made by them were "non-climatic facade designs", "attractive but no due respect to energy issues", and "commercially driven with corporate image" to name a

few. This result supports the notion that “the market is often driven by features and fashions rather than functionality” and glassier buildings without apprehending the notion of “big windows can mean big problems!” seem to be the current trend (Bordass, 2000, p.343).

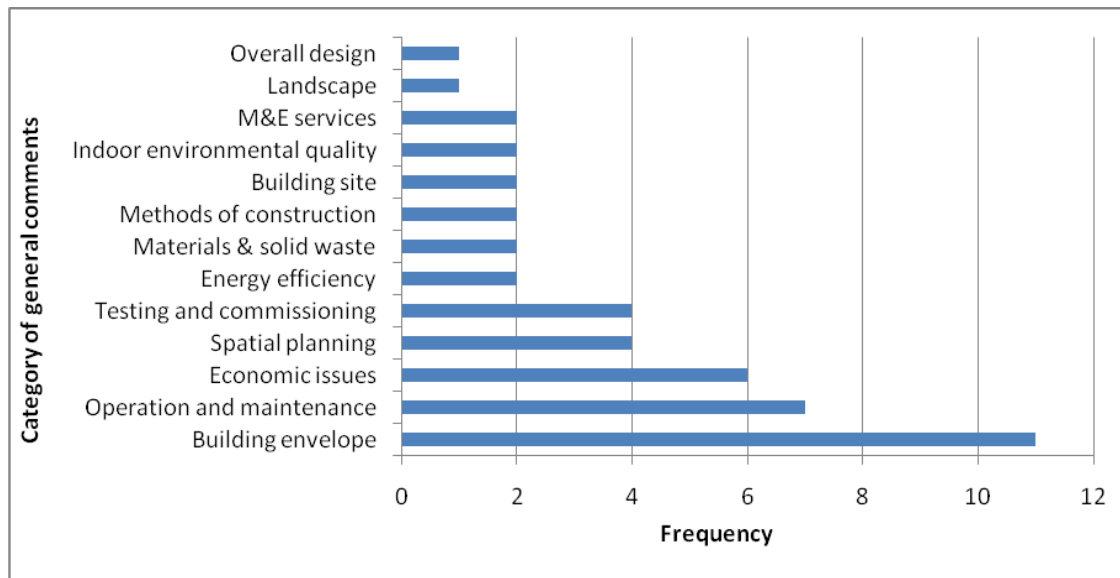


Figure 2: Frequency distribution of interviewees’ comments (in categories of issues) about recently built office buildings in Malaysian cities. Note: Total comments given by 30 interviewees = 43

The second most cited issue concerns “Operation and maintenance” , which represents 16% of the responses. In all but one case, interviewees commented that many of existing buildings are poorly operated and maintained. This view came mainly from interviewees with an engineering background i.e. mechanical engineers and facility managers. They bemoaned the fact that preventive maintenance is rarely practiced and building energy consumption is rarely monitored. This is due to the fact that building owners or tenants normally refuse to employ energy manager especially during economic downturn.

Subsequently, comments regarding “Economic issues” are the third most commonly cited (14%). It is interesting to notice that some of the comments seemed to justify those discouraging comments made under the category of “Building exterior” . For instance, “Most of our developers are concerned with dollars and cents. Nothing is considered from the environmental and social aspects” (Arch/Male/7). The fourth commonly cited are “Spatial planning” and “Testing and commissioning” , each represents 9%. Two issues raised under the former category are: 1) do not facilitate sub-divisions; and 2) without due consideration on the impact on energy use; for example, “Not many people have moved to the total open plan to the perimeter...where the daylight is” (Arch/Female/6). The latter category of comments was mainly raised by mechanical engineers and facility managers. They believed that testing and commissioning are commonly practiced only recently, but it is still considered improper and inadequate.

Other comments are related to “Energy efficiency” , “Materials and solid waste” , “Methods of construction” , “Building site” , “Indoor environmental quality” , and “M&E services” , each represents 4.5%. Arch/Male/5 recognised the state of energy

consumption of office buildings in Malaysia when he said: “A typical office buildings in Malaysia uses 265 kWh/m²/year...We should try to reach 140-150 if we can” . With regard to “Materials and solid waste” , an architect explained the situation: “wrong choice of materials...they have huge carbon footprints” (Arch/Male/4). An interviewee from the Construction Industry Development Board (CIDB) lamented on the improper waste disposal management (especially scheduled wastes) among local builders. One builder admitted that environmentally destructive “Methods of construction” are a normal practice when he said:

It is a common practice among contractors to flatten the whole site, chop all the trees and bare the land during site clearance. Even though the building footprint is small but the site area covers for operation is huge (Bldr/Male/3).

Undoubtedly, this response is consistent with that of the interviewee from the CIDB, who specifically said: “In terms of managing the environment at the earthwork stage, I think it is still not up to the standard. That’ s why we still have flash floods, river sedimentation and so on” (PMaker/Male/4). These criticisms highlight an urgent need to improve knowledge and awareness of all players to ensure commitment, implementation and participation in achieving sustainable construction.

4.3.2.2 To what extent do stakeholders implement sustainable waste management?

Overwhelmingly, half of the interviewees have never specified or experienced using reused components (i.e. not processed, but are simply collected from a demolition site and re-sold) or recycled materials (i.e. processed materials that have already been used). Only eight interviewees claimed the opposite; however, waste recycling is still seen in terms of fly-ash, timber and steel reuse. This viewpoint needs to be expanded to strategies that add much value to reused or recycled materials. Besides, none of the interviewees acknowledged the experience of using recycled concrete aggregate in new concrete. This confirms the views given by two builders which indicate that concrete is currently not being recycled in Malaysia. This can be attributed to the fact that, recycling of concrete and other building materials is a relatively new concept compared to recycling steel scrap, paper, plastics or glass (Ozkan, 2000).

The findings of the interview point to the construction and demolition waste treatment or recovery having yet to be commonly practice, and disposing unseparated and reusable construction wastes in landfills is certainly a common on-going practice. Compared with the early study carried out seventeen years ago by Mohd Nasir *et al.* (1995), the situation remains unchanged, leading to the suggestion that, for these stakeholder groups at least, the progress of implementing sustainable waste management in the local in the local construction industry has been too slow, let alone reaching its tipping point. This notion is further supported by Begum *et al.* (2009) who found that majority of contractors in Malaysia do not practice source separation and source reduction, reuse or recycling at construction sites. All in all, slow uptakes of utilising reused and recycled materials or components in the Malaysian construction industry is reflected by the three interviewees’ major concerns, namely: 1) cost; 2) lack of availability; and 3) perception of “low quality” .

Interviewees among consultants and builders were then asked to explain how the reduction of waste was considered in their design or construction activities. Most interviewees (73%) believed that Industrialised Building Systems (IBS) are one of the most appropriate methods

to be adopted. However, IBS are unfavoured by most of the interviewees as they require higher initial capital investment and tremendous need for technical know-how than does the traditional system; hence, consistent with a similar finding by Badir *et al.* (2002), in their survey among IBS companies in Malaysia. By concerning more on higher costs and efforts (rather than the long-term benefits for both construction business and public) in adopting such technology, it then reflects the local business culture which mainly dominates by pursuing short-term profits among the Malaysian contractors.

4.3.2.3 To what extent do stakeholders utilise ecologically friendly and healthy products/materials?

The interview also examined the uptakes of ecologically friendly and healthy materials/products (e.g. certified timber products, products with low- or zero-pollutant off-gassing) in the local construction industry. It was found that although there was virtually unanimous agreement among interviewees from both sectors that these products/materials need to be exploited in the building industry, most indicated their concerns that impede the widespread usage of these products/materials. The result shows that interviewees, across all stakeholders groups, mainly concerned about the “recognisability” of these products/materials. These products/materials do not carry any certification or eco-label to designate them as being preferable on the basis of consensus standards because of two reasons: 1) no authority to certify them locally, except for local timber products; and 2) they are mostly imported or certified by other countries.

There were also doubts on the adequacy of existing eco-labelling system; hence, cohere with the argument by Lavagna (2006) that it is not enough to have an environmental “mark” on the product that says “this product is environmentally friendly” in the building sector. Consultants need to know the environmental profile of the product, as indicator in the moment of the design choice (Lavagna, 2006). In line with this realisation, one interviewee speculated that these concerns will be addressed in the country within the next five to seven years. This speculation seems to be valid as the SIRIM Berhad, a wholly-owned company of the Malaysian Government under the Ministry of Finance Incorporated, has recently developed “Green Label Schemes” that identify products that are more environmentally preferable than other similar products (SIRIM Berhad, 2012).

4.3.2.4 Why is there a lack of interest in seeking ISO 14001 certification?

As construction is an important industry in any economy, it has an obligation and the potential to make a significant contribution to sustainable development through implementing ISO 14001. Hence, it is important to see the extent to which construction companies seek to acquire registration with ISO 14001. It was found that 10 out of 12 consultants interviewed had never worked with ISO 14001 EMS certified construction companies in their professional career. One asserted that none of his clients insists on this requirement. The response from developers seemed to confirm this notion as 3 out of 5 developers interviewed admitted that ISO 14001 has never been in their contracts’ requirement. This is consistent with the survey results conducted by Tan (2005) which revealed that ISO 14001 has not become an integral part of the local construction companies’ culture especially those who concentrate solely on the local market in which sustainable construction is still relatively a new concept. Those who produce environmentally-friendly products and services in the country are heavily geared towards fulfilling the foreign market demands especially in developed countries where the growth of green consumerism are higher and environmental management is desirable or compulsory requirement. An interviewee from the CIDB asserted that only multinational construction and real estate development companies who venture overseas are motivated and can afford to seek ISO 14001 registration and maintain

the certification.

Two builders interviewed were certified with ISO 14001 and acknowledged that in the area of waste minimisation and pollution prevention, better environmental performance and reduction in operating costs have brought more business opportunities, market share gains and lower cost relative to competitors. Clearly, if a nation is slow in accepting ISO 14001, it is likely that it will lose out in the competition with other nations that are more ready to accept and implement the system. This may have been realised by the government through their recommendation for introducing tax incentives for the adoption of ISO 14001 as one of the key action steps to promote environmentally-friendly construction practices in Malaysia (CIDB Malaysia, 2007).

4.3.3 Current Social Practices

4.3.3.1 Does universal design matter?

Answers to the current state of accommodating universal access (i.e. for disabled people, elderly, strollers and 'abled' people) in office building designs varied. For example, 20% of the interviewees explicitly acknowledged that the minimum requirements have already been spelt out in the *Uniform Building Bylaw* (UBBL) and the *Malaysian Standard MS 1184: Code of Practice on Access for Disabled People to Public Buildings*. Nevertheless, other 10% further clarified that accessibility is only mandatory for government and semi-government buildings; and only to a certain limit for private buildings. Even though that is the case, others clarified the mandatory compliance is still depending on local authorities and their level of enforcement. Other 20% associated accessibility aspect with clients' social obligation but Dev/Female/2 conceded that the aspect had only been considered after being demanded by foreign investors and tenants. Another 20% linked accessibility to the current practice of only complying with the minimum requirements of UBBL and MS 1184. According to GovPI/Male/1, merely complying with the minimum requirements would result in disjointed facilities i.e. not covered throughout development.

These responses seem to be in line with views from the remaining 30% of the interviewees which indicate that many consultants still choose not to conform with universal design guidelines; hence, the progress in creating such environment in Malaysia moves at a snail's pace. This can be attributed to the fact that the use of the Malaysian Standards in designing and building physical development of a city is voluntary unless the regulatory authority of a particular city regulates it as mandatory, interviewees saw the efforts as only focusing on complying with the minimum stipulated requirements with no sense of reality and compassion. The consultants' neglect of the universal design might be the result of lack of knowledge on how to design built environment in compliance with the requirement of the universal design (Heylighen, 2008). Clearly, universal design in Malaysia is "still perceived as a pedagogical process, rather than legally enforceable compliance practice (Abdul Rahim & Abdullah, 2009, p.50). Since current efforts only focus on complying with the standard's or local authority's minimum requirements, stakeholders need to be rewarded for their initiatives to go beyond the minimum requirements stipulated in the UBBL and MS 1184.

4.3.3.2 What is the place of education and training in sustainability issues?

Realising the fact that there is still a wide gap in knowledge and awareness on sustainability issues in Malaysia, interviewees unanimously support the importance of relevant education and trainings, indicating their positive attitude towards improving their knowledge and understanding. Haron et al. (2005) pointed out that the more environmentally knowledgeable

respondents tend to have more positive environmental attitudes, which in turn increased their environmental behaviour and participation.

However, when investigated in terms of the interviewees' environmental behaviour and participation by means of using tools to assist their sustainable design, construction, development or maintenance, it was found that 57% (or 13 out of 23 interviewees from the private sector) had never used any. Only 3 architects and 1 building environmental consultant have used "building simulation tools" while many of them still preferred to make decisions and assess their building performance based on intuition. This can be attributed to the fact that the usage of predictive and assessment tools are not easy and time consuming (Papamichael, 2000). A few interviewees among consultants rationalised their disregard on any simulation tools by stating that energy or environmental specialists are more likely to assist with suggestions for design changes with potential to improve performance. Unfortunately, in Malaysia, these specialists are very limited in number. The only energy/environmental consultant interviewed in this research proudly admitted that his company is the only company in Malaysia that has the capacity and expertise to provide such services for public and private clients (only likely to be true in 2009 when the interview was conducted).

4.3.3.3 Can the culture of feedback be practiced more widely?

In use, buildings do not always work as intended. Some features perform better and some worse. Different things happen which nobody anticipated; therefore, the stakeholders were asked whether it was important for them to know how the building that they had designed, built, or developed performs during its occupancy period or how satisfied occupants were with the building's indoor environmental quality. This part of interview aimed to investigate the extent of post occupancy evaluation (POE) been undertaken by design and building teams in the country.

The result shows that there was virtually unanimous agreement that feedbacks that could help clients obtain information on the performance of their completed projects were very important. Three reasons were suggested, namely: 1) to provide a continuous learning process; 2) to eliminate the current poor practices of building maintenance, hence reducing the problem of Sick Building Syndrome (SBS); and 3) to maintain good reputation. Accordingly, there is a tendency to initiate programmes of monitoring and benchmarking either by owners or design teams, as part of a culture of feedback, service and continuous improvement.

It was found, however, that POEs are far from being a 'mainstream' activity within the construction and property sector because it is not a requirement or of interest to the client. Apart from acknowledging the lack of awareness among local building owners, these interviewees recognised that in practice, most private organisations were unable to cope with feedbacks and could not (or thought they could not) afford it. Hence, the industry has been slow to learn from completed projects, particularly when they are already occupied. Evidence for this is that consultants are almost never paid to go back and review the outcomes of their design decisions (Zimmerman & Martin, 2001), particularly when the clients are not the tenants of the building who have little financial benefits of refurbishment to save energy bills.

4.4 SUMMARY AND CONCLUSION

The paper has drawn on in-depth qualitative research undertaken with thirty stakeholders from various backgrounds in the Malaysian construction industry to gauge their different views on the extent of sustainable development practices in the country. The study finds that economic issues have always been the first priorities among stakeholders in any decision-makings for building projects and minimising capital or construction cost has been perceived to be more important than minimising long-term operational costs. As such, cost becomes one of the major reasons for the slow progress in implementing environmental-friendly practices in building projects. Cost also seems to be one of the reasons for the lack of interest in seeking ISO 14001 certification as well as demanding for POE studies to be conducted on existing buildings in the country. Besides economic issues, there is still a wide gap in knowledge and awareness on sustainability issues among stakeholders, explaining the lack of commitment in achieving social sustainability.

In conclusion, it is obvious that the progress that has occurred in terms of developing the culture of sustainability among local building stakeholders is rather slow. The results of this study offer some support to the notion that sustainable construction practices suffer wide gaps in developing countries in which construction sector still maintains a large share in total domestic production; however, cannot afford sustainability at any cost (Bon & Hutchinson, 2000). Although the rise in concern for sustainability is now embedded in many government policies and initiatives, it is still not integrated into the Malaysian property development and investment practices. Whilst the last decade has seen progress towards ‘green government buildings’, there has not yet been a ‘sea change’ in market behaviour.

The question remained is what measures might be effective to move the industry players to close the current gaps of sustainable building practices and to reach significantly higher performance levels, and in a broader range of performance issues than just energy. Currently, financial incentives for going green have started to be provided in Malaysia and this effort should continue because a financial inducement is likely to be effective in an environment where financial return is a primary objective. Bon and Hutchinson (2000) argued that market-oriented policies or economic measures, such as incentives and taxes, are much more effective in delivering sustainable construction than those which involve legal regulation and impositions. However, it is recommended for specific issues highlighted in this paper to be collectively addressed by the government and regulatory stakeholders, research and education sector, private sector, and clients of the building industry in order to make sustainability more socially acceptable and integral in the local construction industry.

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5 Vernacular solutions for managing energy use in mountain areas with cold and dry climate: Case study of Azerbaijan – Iran

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Abstract: Understanding vernacular way of energy-saving and providing low-impact thermal comfort in the building of every region may have significant impacts on developing well-established green strategies for the new architecture for that region. The conducted preliminary desktop research revealed fundamental similarities among architectural approaches of different regions of Iran. The conducted literature review also revealed that much research has been done for exploring different angles of vernacular sustainable methods of architecture in central arid zone of Iran which is often recognised as the representative of the traditional architecture of Iran; as this part already contributes to almost three fourth of the total area of Iran. In other words, the creative methods of adopting sustainable architecture in other parts have been neglected by far. This fact also applies to the well-established vernacular architecture of Azerbaijan the history of which backs to more than 10,000 years ago. This research investigated the innovative methods through which the architects of cold and dry Azerbaijan managed energy use in the vernacular buildings. The study adapted field studies as well as archival research followed by qualitative methods of content analysis. The research discovered the similarities and differences between the vernacular methods of energy saving in this part of Iran and those for the arid central parts of the country. The results revealed that although there are a lot of similarities between these two architectural styles, the traditional architects of Azerbaijan have had various innovative and sustainable methods in construction and structure of the buildings which are exclusive for this region only. This research contributes with highlighting particular and significant approaches of the ancient sustainable architecture of Azerbaijan which could be used as a reference for further development and adaptation in designing new buildings in this part of the world.

Keywords: Azerbaijan, Iran, Energy Usage in Buildings, Vernacular Architecture, Climate

5.1 INTRODUCTION

Climate in Iran has different types and each one of these climates has harmonic architecture based on their situation. Many parts of geographic range of Iran have hot and dry climate and are considered as arid zones. Because of this point, many researches related to architecture and urban designing have focused on this climate; therefore little study have been done on the features of the architecture and urban design in other climates. Azerbaijan area in Iran has cold and dry weather and it leads to differences in architecture of this area compared to those for the arid central parts of Iran. The main question of this research was whether there is any difference between the architecture properties of Azerbaijan area with those for the central areas of Iran? Therefore, the study aimed at studying for finding the differences between these two areas in terms of architectural characteristics in terms of managing energy use. The importance of this study is that since little studies have been done for finding the diversities between the architecture of different areas of Iran with respect to climate, the architecture of Iran has only been represented with the architectural characteristics of the desert areas; hence lack of reference in understanding vernacular patterns for guiding today's architecture in Iran.

5.2 RESEARCH METHODOLOGY

This study adapted an explanatory historic research method which collected data through

field observations, building surveying, and the review of literature; in order to reveal the significant characteristics of different types of buildings, e.g. residential, commercial, religious etc, in both zones. The analysis was based on documentations of the existing samples in the both areas and through matching the type of architectural pattern that is influenced by the climate of the areas. The study classified these differences based on the major and basic diversities between the architectural characteristics of these two areas.

5.3 RESULTS AND DISCUSSION

This section reports the results of the conducted study based on the criteria mentioned above. Since this was a qualitative study, the discussions are directly associated with the results.

5.3.1 *The geographical position of Azerbaijan*

Azerbaijan is an area which has located in the north-west of Iran. This area has cold and dry climate and is one of the highest geographical places in Iran. Azerbaijan is a high area which is limited to different highlands from all directions and these highlands lead to creation of numerous plains, namely Moghan, Tabriz, Sarab and Maragheh. The highest place of the province, Sahand peak (3722 meters) is located at the south of Tabriz with 50 kilometres distance. The lowest place of this province however is near to the Oroomieh Lake (1220 meters) (Shaterian, 2009). The aforementioned geographical position, altitude and maintains lead to cooling, raining and snowing weather in certain seasons of the year in Azerbaijan. In other words, this part has significant temperature and weather differences with central areas of Iran with hot and dry weather and very low precipitation. The other difference is that in contrast to the central parts of Iran, the temperature difference between warm seasons and cold seasons of Azerbaijan is very significant.

5.3.2 *Architecture highlands with cold and dry climate*

Climate has direct impacts on shaping the architecture. This effect has totally been clear for construction in different climates before the growth and expansion of the telecommunications industry. This idea comes from studying the historical parts of the cities and villages in different geographical positions. Using green spaces, using aqueducts for managing underground water abatement from Sunlight exposure etc in warm and dry areas, have been important for architecture; whoever in the mountain areas, greater use of sun energy in cold seasons, suitable solutions for reducing energy transfer between inside and outside, warming spaces in the cold days of the year etc have been important for the architecture of the mountain areas.” because of the extreme cold in the heft of year, in these areas, urban fabric is dense and buildings are joined together for reducing contact between the buildings’ inside warm spaces and outside cold environment. Urban spaces are also closed and small as much as possible for decreasing leakage of cold wind flow into inside of the buildings. In addition, heat radiation through external surfaces of buildings’ warm walls, to some extent, leads to the moderation of cold weather of urban spaces and smallness of these spaces are also benefit in this situation (Ghobadian, 1994). Attention to the components which have been demands and needs of residents for continuing their lives leads to a special formation of architecture in these areas that have basic differences with the architecture of the warm and dry climate in the central areas of Iran. In these areas, buildings are joined together and materials are usually adobe with the arch and dome coatings. Communication arteries are narrow with high walls in these areas for preventing direct sunlight and draught of winds’ disturb in the specific seasons of the year through this way. High walls beside passages have a significant influence for providing shadow against sunshine and also protecting passages against desert winds (Ghobadian, 1994). Then,

architecture in different areas of Iran based on different climates, has diversities in some of the architectural components such as: Orientation - high ceilings - Design and construction - tissue density in rural and urban areas - water usage - green space and trees - create shades and suitable cover for preventing energy waste. In continue, this paper will analyse each of these above cases.

5.3.2.1 Orientation

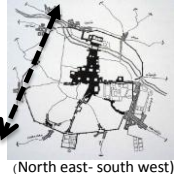

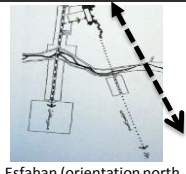
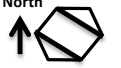


Orientation for constructing building is one of the significant features of Iran' s architecture and urban design. It means that in addition to environment and topography and slope of the ground, climate and the influenced weather have direct impact on choosing the orientation of the buildings. One of the important issues is related to the urban and that is the orientation of the house. It relates to the weather, the radiation, direction of the wind (air conditioning, wind, dust, wind etc), and the location and the material of the ground (Pirnia, 1995). In the past, architects based on their experiments, knew that one of the important and effective factors in architecture is wind direction and also they were aware that understanding the quality of this factor has effect on providing environmental comfort. For instance, different studies showed that Tabriz, as the most important city in Azerbaijan, is a deals area and at the many days of the years local winds are blowing; but Tabriz has some dominant and important winds which general direction of construction in the local architecture are formed based on these winds. The most popular of them is East wind which blows from the east throughout the year and the other one is North-East wind that based on the frequency and intensity of wind, is more that all the winter' s wind" (Management and Planning Organization of Iran). There are three main axes for orienting buildings and cities. Grouping these three axes show the point that most of the cities in Iran have given attention to the wind direction for orienting buildings. The researches which have been done in Tabriz prove this claim. Generally we can say the orientation of buildings are to the South between 15 degree East to 10 degree South-West so that the main spaces that have located in the north face such as Tanaby, dumb and living room are located at the south (Key nejad, 2010). Also, multiple windows and patios t the south in mosques such as Ostad Shagerd mosque and Haj Safar Ali in Tabriz and Bonab and Maragheh show the importance of the orientation of buildings for the local architects in Azerbaijan area. On the other hand, the main patios of mosques in the centre of Iran are to the north. This form of direction in terms of Ron order besides other existing Rons in Iran can be studied and checked; and it is the only direction of Ron of Persia trilogy which is coincident to the Muslim prayer. The orientation of this Ron is from North-East to the South-West and the orientation of different types of architecture shows that beside religious orientation appropriate use of capacity of the natural environment has been important for manufacturers. Table 1 illustrates the differences in the Rons of different parts of Iran.

5.3.2.2 Ceiling height

Because of the warm weather of the central area of Iran and the need for cooling in the many seasons of the year which have had temperature more than body temperature, it was required that the height of coatings for constructing buildings was higher; but in Azerbaijan area, because of the temperature and low temperature environments, the height of coating is much shorter and less than height of coating in the centre area of Iran. This point is observed in public and commercial areas such as historical market beside residential and religious areas. In these areas, especially in the north and North West of the country [Azerbaijan] cold and sleet are important determinant factors in the shape of the buildings (Ghobadian, 1994). Of course, there are some exceptions, sometimes, in these cases and some applications based on developers wanted are contrary with this public phenomenon so, in the buildings that developer wants have been index of space toward other buildings, heights are higher than usual, but this point cannot be generalized. The height of vault

orders also depends on the business and economy importance of each order, so that in the important orders such as Gheisarieh and or the parts in which commodity price is sold, the height of the vault order is more than other parts (Department of Housing and Urban Development, 2009) or in the Kabood mosque and Tajeddin Alishah mosque of the Tabriz, Marand mosque, Orromieh and so on because the developers want has been based on the index of the design the climate factors have not been considered, but in the most of the neighbourhood mosque, the height of the arches are lower than city and state mosques.

Table 1: The differences in the Rons of different parts of Iran

City map	General direction	features	Shaping the overall direction	Row
 <p>(North east- south west) Tabriz</p>	<p>Orientation north east- south west</p> <p>North</p> 	<p>Building orientation is based on the jersey and adjusted according to the skylight and the prevailing winds</p>	<p>Order Ron</p>	1
 <p>Esfahan (orientation north west – south east)</p>	<p>Orientation north west- south east</p> <p>North</p>  <p>North</p> 	<p>Iranian center buildings are created in this direction for the optimal use of natural energy</p>	<p>Esfahani Ron</p>	2
 <p>Kerman (orientation west-east)</p>	<p>Orientation west-east</p>	<p>Buildings are created based on the climate issues, avoid sharp gust of wind and solar radiation control</p>	<p>Kermani or Shirazi Ron</p>	3
<p>Ron: the orientation of the house or any building in the traditional and native architecture of Iran which is measured based on the exposure of rectangle into a hexagonal</p>				

5.3.2.3 Construction

Constructional features of different parts of Iran are summarised in Table 2. Central parts of Iran, because of climate, have resistant woods against natural hazards such as weather and insects; then in construction of buildings use of arch and dome is usual and in requiring cases for constructing buildings in the past woods from other countries for architectural have been used. Because there is a shortage of wood Iran, the bed cover shape always has had problems. In the time of Hakhmaneshian, the rich empire of Iran, they also provided the resistant wood such as wood of the cedar tree from Lebanon and other far places with high expenses for covering their palaces. The reason which made impossible the use of wood for covering in some places was termite. In the most of the Iran' s land termite are prone (Pirnia, 1994). This factors leads to using arch and dome covers in the centre part of Iran has become a tradition, but the situation in the other parts of Iran such as Azerbaijan and north of Iran is different. In these areas, wood is a suitable material for covering building surfaces and almost except buildings such as some mosques, bathrooms and main pass Bazars, using of the bed cover has been common. On the other hand, using arch and dome in these buildings needs special situation which they have and humidity of the bathroom and fear of fire in public buildings limit the use of bed cover; but the use of this cover in

residential buildings of the city and village through using wood in the form of flat or steep has happened by woodworking trusses, but in all the residential buildings of the city and village in the centre areas of Iran using arch and dome has been considered by developers.

Table 2: Summary of constructional features of different parts of Iran

Architectural Features							Cities	Climate Features	Iran's Climate and Weather
Green Spaces	Water	Sunshine	Roof's Cover and Form	Orientation	Height	Texture			
Lots of green spaces due to the high humidity environment	Rainwater and many rivers	Creating awning (porch) around the spaces	Covered steep slope to direct rainwater with the use of wood	Orientation is for the goal of creating Kuran for circulating air inside the house	Height of spaces are low but height of buildings are high because of the gable roof	Wide texture-separate buildings-narrow streets-allowing circulation between buildings	Ghorghan -Babol-Sari-Ramsar-Rasht-Masooleh-Lahijan	Plain areas with high rainfall-high humidity environments - with less temperature fluctuation	moderate climate-southern shore of Caspian sea
Little green spaces around the building	Existence of cistern in the house for daily usage	Lack of the direct use with creating porch in front of the building	Bed covered with arch views, wooden material in the main facade	orientation towards sea for creating Kuran	High height rooms with pulled windows	Dense urban - rural to some extent open texture - semi-enclosed urban spaces - a buildings towards the sea	Shoosh-Shooshtar - Chabahar -Bandar abbas-Gheshm-Booshehr -Ahvaz	High humidity - very hot air in summer and mild in winter - very little vegetation	hut and humid climate
Very little green spaces limited to the house yards	Using canal and water storage for water use	Creating porch and awning in buildings and urban spaces	Arch and dome covers with the use of brick and adobe	Eastern-western orientation based on the Shirazi and Isfahani Ron	The height of roofs and covers are very high because of the warm weather	Dense urban - closed urban - narrow and irregular streets - joined buildings - establishment based on the sun and wind	Isfahan-Kerman-Yazd-Natanz-Bam-Naein-Ardestan-Shiraz...	Low humidity in the air - very little precipitation - less vegetation cover - Strong winds combined with dust	Hot and dry climate
appropriate amount of green spaces and vegetation	Using river-water well and sometimes water storage	Using sunshine for more heating spaces	Bed covered with wooden materials and using brick arches sometimes in public spaces	the northeast-southwest orientation based on the Rasteh Ron	The low and short heights for floors and covers	Confined and small city spaces - compact and connected buildings - the streets are often narrow and narrow	Tabriz-Ardabil-Hamedan-Qazvin-Tehran-Sanandaj-Shahre Kord-Orooomi-eh	Extreme cold in winter, warm in summer - heavy snow - low humidity air - relatively low rainfall	Cold and dry climate

Suitable climate and existing areas with the ability of breeding wood has caused in cities like Maragheh, Bonab and Ajabshir an especial form of mosques named wooden mosques Shabestani been formed which have flat covering of wood with decorations and wooden structure. An example of using wood for covering in this form can be seen in the Aali Ghapoo and Kheshte Behesht palaces which have been pattern taken from the wooden mosques that have built in the early Safavieh in these areas. The method of building wooden cover has been taken to the Isfahan, the capacity of Iran in those days, 100 years later and helped to the construction of the magnificent palaces like Ali Ghapoo, Chehel Sotoon, and Hasht Behesht (Kheyri, 2006).

5.3.2.4 Tissue mass in urban and rural area

Iran is a country in which religious believes always has effect in formation of quality of architecture and urban. This point has impact on creation of closed areas especially in residential spaces' architecture; local architecture in Iran always has tried to pay attention to the climate issues for favourable use of the city space beside the doctrinal issues. The role of the environmental factors in urban context in the past have been crucial and decisive completely and can say that the context of each city in that time has represented the situation of natural factors of the area and environment in which city was formed (Soltanzadeh, 2011). In Iran, because of existing of the different geographical climates, urban context can be divided in two groups which are continuous and dense tissue (Tavasoli, 2002). Continuous tissue are context that has shaped in the centre parts of Iran and Azerbaijan and discrete tissues have been context that have shaped in some parts of the south west and north of Iran, but because tissues from centre parts of Iran and Azerbaijan area have been continued together, these areas have differences with each other. In the centre areas of Iran, beside adjoin, the existing ratio of the surface to the volume of buildings built are much more than Azerbaijan area and it leads to more density in tissues in the cold climate in compare to the tissues in other parts. Cold areas of the country almost have dense tissue (Soltanzadeh, 2011). To some extent city spaces are landlocked and small to control the leakage of the cold wind flow into these spaces (Ghobadian, 1994). Arteries in the urban and rural context of Iran have few of width and sometimes are built for crossing one or two persons and in the centre part of Iran for preventing direct solar radiation, awning and shading have been used, but in Azerbaijan because solar radiation has not been annoying for people rarely these elements have been used.

5.3.2.5 Water use

Different parts of Iran are like areas of the world which have limited water resources that is why settlement and Housing in one geographical point depends on solving the problem of access to water. Mountainous areas and marginal seas that have appropriate proportion of water and by building mills, stone and break dams and diversion routes and in warm and dry and waterless desert areas by building canals and water storage and some elements like these, they could manage water for survival. Existing of water natural resources in the form of river and spring in mountainous area leads to differences in ways of water use in these areas in compare to centre parts of Iran. In the desert and centre areas of Iran using of cistern is suitable because of the lack of surface water based on nature and climate of these areas.

It has been as a reservoir for storage and use of water and this leads to shaping a certain type of architecture which named cistern in these areas. One of the cities which have popular cisterns is Kashan. Natural environment and situation, lack of surface or river water and the conditions of the warm and dry weather which ruling in desert areas caused to special position for cisterns in Kashan (Farrokh Yar, 2007). Cisterns and the possibility of using them in all seasons of the year help to the residents to be able to live, but in the

mountainous areas and because of existing natural flowing streams and rivers beside aqueduct that made by the inhabitants use of water appear in this area in other form. In these areas cisterns almost have located in the historic buildings underground within the enclosure of yards or green spaces and inside the big buildings and the usage of those have been personal and belonged to the residents of that building and because the groundwater levels in compare to the desert areas has been higher, most of people could use the water from the water wells which has been in their houses.

Presence of water in open and semi-open architectural spaces could help to heat exchange of the space in the warm season of the year. As presence of water resources in macro climate can lead to temperature moderate during the day, inside the building can also reduce temperature fluctuation as a micro climate (Ghobadian, 1994). In the centre spaces of Iran, water in architecture can be seen in the form of long pool with low depth in open spaces, and in the semi-open spaces water can be seen in the form of cellars and pools in most of buildings and public and religious spaces and Persian gardens pavilions and it has been their resident's need for setting the environment for their life comfort, but in the Azerbaijan areas water was used for consumption stead of using for setting the environment. Presence of small and compact pools in open spaces and decorative pools with Granit and marble inside the spaces are some of the forms of water use in Azerbaijan areas and their differences with centre areas of Iran.

5.3.2.6 Green space and tree

Tree has been an important element for Iranian before and after the Islam and planting and maintenance of that has been a ritual practice. This is presumable Iranian religious texts: Zartosht tells Ahuramazda: creator of the material world, who is the fourth one who provided the pinnacle excited for the land? Ahuramazda answers that the person who the most vegetable plants and most tree takes (Pirnia, 1994). In the versus and Islamic traditions and Quran the holly book of the Muslim also exist a lot of references about the importance of the tree apart from doctrinal issues, using of tree and green spaces in living spaces based on climate and environmental situation has been necessary for Iranian. Presence of plants besides improving relative Humidity, caused shadow in the spring which decreases high heat and sunshine (Ghobadian, 1994), but the use of tree and green spaces in mountainous areas and Azerbaijan is completely different in compare to the desert and centre areas of Iran. In the centre of Iran existence of plenty of trees inside the big yards provide a suitable environment for living and decrease the ambient temperature largely. Existence of yard and green spaces is necessary, but in the Azerbaijan area yard is not important as much as centre areas and even index and large structures such as Kabood mosque, Marand mosque and most of neighbourhood mosques have not had yard and. Green spaces and yards in the residential centres are not as big as yards and green spaces in the centre of Iran and all efforts have been in this direction that they could exploit from inside spaces as much as possible. Trees have been used for decorating the yards, but in the centre areas of Iran trees which have had more ghosting have been used.

5.3.2.7 Creation of canopy and appropriate cover for preventing energy loss

If we look at the existing types of architecture, we will see some important factors for preventing energy waste. In the buildings of the centre of Iran, porches and buildings in the middle which have been existed in Azerbaijan areas' buildings have not been used. Porch provides shadow in summer and becomes a buffer for keeping heat inside in the winter. This porch also protects windows, sash and frame houses against climatic factors such as rain (Key Nejad, 2010). Existence of snow and rain in the cold seasons and wooden door and window caused exhaustion for outside doors and windows. This issue has been more visible

in the doors and windows of the main façade that had expensive decoration, but existence of porch above them besides climate working, has prevented their further damage.

Creation of the entrance atriums that work like a space between outside and inside space and prevent losing energy, existing porches, long porches in the main façade of the buildings show the Deep-thinking of architects for harmonizing the climate and architecture or creating double glazed windows in most of buildings in different shapes is also one of the architect's deep-thinking and or creating drainages, doubling roof covers have been for the goal of reducing energy loss especially in the cold seasons of year, but in the centre areas of Iran using high and open spaces is for reducing temperature in close spaces. The summary of

5.4 CONCLUSION

Comparing the architecture of central parts of Iran with hot and dry desert climate and the architecture of Azerbaijan area with cold and dry mountain climate have shown that these two architecture (because of having natural geographic and different climate with each other) have diversities in their shape, form and structure and each one of these architectures could shape their architecture with matching their architecture by their natural environment which are responding natural needed and their residents demands. These differences can be identified through these characteristics of the building:

- Orientation of building's construction and urban and rural contexts in these two areas are completely matched with climate and weather; so that orientation of buildings in the centre of Iran mainly are based on the East-West axes, but in the Azerbaijan area are based on the north East-Southwest axes and this point has had direct effects on the architecture and urban.
- In the central areas of Iran. because of existence of hot weather and direct sunlight in different seasons of year and the need to cold environment for residents' comfort, the use of cover up roofs has been residents' demand, but cold weather in Azerbaijan leads to shortening height of roofs and minimization of existing pop out in architecture until can find an appropriate environment for comfort and life.
- Damages caused by the natural factors and insects and lack of existence suitable wood for covering roofs in the centre areas of Iran leads to orientation of local architecture for using arched and curved coatings with material such as adobe and brick and sometimes stone; but environment and suitable wood has caused that flat covering with wooden material has been one of the common form of covering in Azerbaijan, and using arched coverings because of the exception and developer's demand and fear of public fire leads to using arched covers in a few cases in commercial and religious spaces.
- Central areas for optimal use from environment have bigger and more open spaces, but in Azerbaijan area, heating and preventing energy loss were required a need for more density in construction and the ratio of volume to surface in Azerbaijan area is less than centre areas of Iran.
- The way of water use in central areas of Iran depends on the groundwater and the big cisterns have been an space for storing water for low water seasons, but existing springs, aqueducts and shallow groundwater in Azerbaijan area leads to differences in the method of providing and using water in compare to architecture of centre of Iran.
- Using of trees and plants in the central areas are more for shadow for comforting in the hot season of the year and through this way and heat exchange which has been

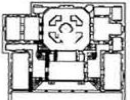
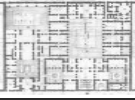
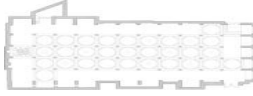
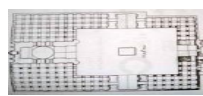
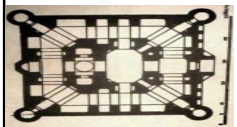
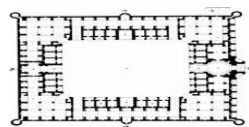
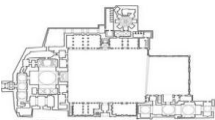
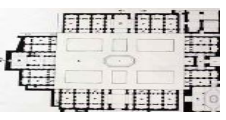
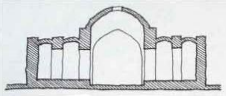
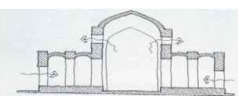
between trees and plants by the environment architects have tried to provide colder environment for residents, but the cold weather of Azerbaijan area has caused using more trees for decorative.

- Porch in centre areas of Iran has had function which has been providing a semi-open space for living in the hot season of the year, but in Azerbaijan existing long porch has been used for creating fender between close space of building inside with yard to prevent energy loss and destruction of doors and windows with expensive decoration.
- These characteristics are summarised in Table 2.

Notes

1. The term Ron or direction has been a term that Iranian traditional architects have used for the direction of traditional buildings in the past and in general Classification Iran has three main Ron which are Rasteh Ron, Esfahani Ron and Kermani or Shirazi Ron.
2. For instance in Kashan's buildings the use of semi-opened and high spaces in front of windows forums and main rooms of houses, or Agha Bozorg mosque-school has been a way for providing more shadows and proper air circulation for reducing environment temperature.

Table 2: Summary of the differences in characteristics of architecture in different parts of Iran

Climate matching to identify differences and similarities	Cold and dry climate		Hot and dry climate		Architectural type
	features	Plan or section	features	Plan or section	
Ratio of the surface to volume in the arid areas are much more than cold areas and it cause the greater tissue density in cold areas in compare to arid areas	Because of the cold weather in most seasons of the year, spaces are confine, height of roofs are shorter and pools in yards are small	 Behnam house in Tabriz	Houses have semi-open spaces for using in hot seasons of the year, yard in these areas are big with large pools	 Navab house in Yazd	house
In cold areas yards are non-use in the most season of the year, then all architectural events happen in mosques	The plan of the mosque is closed, without yard and with Shabestani form, has the least number of openings for contact with outside	 Hojatol Eslam mosque in Tabriz	Mosques have a central courtyard with four-iwan plan and have a large dome to the jersey side of mosque with large number of openings	 Goharshad mosque in Mashhad	mosque
Because of the cold weather in the cold areas, karvansaras do not have yard, then the center part in their plan is covered by dome or arch	Karvansara's plan are closed without yard and the place for protecting animals is a part of the karvansara in the plan	 Shabli karvansara in Tabriz	Karvansara's plan is in the form of a central yard with cells around it and the place for protecting animals is behind the cells and also cells have porch for connection through yard	 Madar shah Carvansara in Isfahan	Karvansara
Schools in the cold areas have designed in a form which has more closed spaces and cells have connection with outside by using filter and also the green spaces inside the yard of this areas has lower volume	Cells have connection with yards through auricular and training is in the close spaces	 Seyed Hamzeh school in Tabriz	Schools have four-iwan or two-iwan plan and cells have connection with yards through the porch and the training is in the semi-open places	 Ibrahim khan school in Kerman	school
Extreme cold does not let to create large openings and also height of the domes are low, then Bazars in clod areas seem to be much darker	Height of covers are low and have least number of openings only in the center of domes and some openings in besides	 Bazar in cold areas	Height of covers are high with opening in the center of dome and besides for skylight and air conditioning	 Bazar in arid area	Bazar

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6 Improvements of home quality with truth Elements

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Abstract: Home as a place of residence has the most extensive and intimate relationship with the human being. Home is a materialised form of space although its material entity extends beyond spatial dimensions. Aspirations, needs and value systems of the human being are directly affected by the conceptual, non-physical and sometimes humane aspects of homes, which make home a special functional attribute. Home provides a place for sheltering and simultaneously maintains human values. This research is an attempt to the understanding of the current status of home as a multifunctional entity and hypothesises that the existing homes lack proper designs and properties to help realisation of a transcendental life for their settlers. Considering the materialistic aspects of homes without regard to the quality is one of the major causes of emotional and spiritual problems of the contemporary human that segregate home settlers from their innermost needs and make them alienated. The main objective of the present paper is to strive to improve the qualitative aspect of home by directing and harmonising the holy and the highest desires and requirements. One of these desires is the element of truth, which will be explained in the present paper. Considering this goal, the way the truth element will be elaborated. Emergence of the element of truth in the real house makes home a place of stability and optimality and in the form of immaterial makes course of genuine thinking and the ability to get to the real truth of nature provides. The best examples of this issue are in the vernacular architecture. There are features that lead home toward being an ideal home and ultimately these features improve the quality of home.

Keywords: Residence, Home, Element of Truth, Qualitative Aspects

6.1 INTRODUCTION

The familiar concept of home is a place where we spend a lifetime in it. It is the best place to invite and serve guests, the safest place to rest and contemplate, the most quite place for self-consciousness, the most comfortable place to move and change and the loveliest environment to live a happy life. Home in either its temporary or permanent form carries in itself a set of concepts, meanings and cultures. Anthropologists have used the hidden meanings behind the concept of home and habitation to investigate and understand traditional and local cultures. Home is the most proximal space to human and because of that is the most directly affected environment.

Being conscious of the quality of human life means an awareness of human values. Intrinsic human values are those transcendental values that drive and invoke a sense of disposition towards fidelity, benevolence, beauty, truth and love. Among these is the key value of truth seeking. A home which is build and shaped based on the element of truth seeking is a dwelling that gives an ultimate sense of satisfaction and utility to the settlers and plays a key role in the transcendental life. Presence of the element of truth seeking in a home creates a set of properties that this article aims to unveil and reinstate their architectural manifestations.

A Home designed and built upon these moral elements provides a sense of intimacy and durability for the dwellers. A home built in such a fashion would in effect convey the sense of confidence and unity, utility and freedom of choice as well as the sense of contentment and attachment. Living in a home rich in moral content fosters an improved quality of life, which is consistent with the idea that humanity takes meaning by the existence and dwelling (Heidegger, 1971). A home with these properties is in essence a place richer than a physical residence; rather it is a dwelling that makes humanity to grow

and develop.

This research follows a qualitative approach and deploys a logical reasoning to systematically investigate the truth of the hypothesis that relates the quality of home to the elements of sustainability enriched by the human moral desires. The elements of sustainability are those commonly understood elements which are enriched by the human collective wisdom through a historical, cultural and intellectual evolution and shaped the human integrity and communal identity (Nadimi, 2007). Truth seeking is in this context one of the key elements of sustainability. This article will discuss the concepts of dwelling and habitation needs and introduces the element of truth seeking as an emerging property of homes in the contemporary life.

6.2 CONCEPT OF HABITATION

The choice of place for sedentary and fixed place habitation by early humans was developed following the stone-age and by the emergence of plant domestication and agricultural evolution. The need to settle down in fixed territorial settings developed early human communities to choose a form of territorial settlement and started shaping dwellings and building permanent habitats to reside. The need for stable territorial habitation was a product of human development in domestication of plants and animals (Rappaport, 2001). This form of stable habitation reduced the need for movement and encouraged the growth of self-consciousness in the so called sedentary human. The word habitation conveys both the meanings of dwelling and settlement. Settlement emerges after human settles down and experiences a long stay in a dwelling, which is different from a night-long temporary habitation. Heidegger argues that dwelling is a mean to establish peaceful harmony between the individual being and the universe and is built by allowing a space into which the elements of earth, heaven, divinities and mortals are consistently unified. Dwelling can be seen as a mean to self-actualisation of human identity. Dwelling provides an opportunity for human to actualise his potential being. Human dwelling allows a state of self-awareness, which in turn leads to transformation from a state of being to a transcendental state of becoming. Heidegger defines dwelling as being with things, where one should go further to explore means to becoming after coming up to existence. Dwelling makes it possible for human individuals to realise self-awareness and consciousness. Levinas (1971 and 156) defines dwelling as a state of revision, a self-awareness, a retreat into one's ego and to finding a dwelling on earth. Finding a place to invoke self-awareness and exploring the essence of being is associated with the creation of an ideology of the self and the universe. Establishing a firm relation with the universe sheds light on the perception of one's position with respect to the environment. Cooper Marcus holds that dwelling is the creation of one's world and argues that by taking the responsibility of creating a world to live, humans not only relate any disorder in their home to a larger scale universal chaos but also build their own little houses as to resemble the world of gods and would eventually sanctify the place; and it is for this reason that building homes in all forms from villages to houses is in fact a reflection of a solemn decision by the creator for it involves survival of the human himself (Clare Cooper, 1995).

Habitation and dwelling can be seen as the beginning and end of the human's pathway to existence in this world (Norberg Shulz, 1984). A pathway with a beginning and end that exists to reflect the purpose of creation. Being aware of how to set up and reside in a dwelling can ease the way through. Such a dwelling empowers a silent contemplation under the veil of fantasy and imagination. It has its origin in the human's life and proceeds towards the purpose beyond human creation. The human in this realm of habitation is supposed to experience events of the nature that imply a state of becoming, passing through, exploring and transforming from being down to earth to a celestial life in heavens. All these features suggest the idea that the ultimate purpose of dwelling is to reach out to the truth

through self-discovery, self-awareness and transcending to a state of peace and wisdom and that dwelling is the human' s footprint to the excellence.

6.3 REQUIREMENTS FOR HABITATION

Home is a place to rest and reside to find the purpose of life. In home it is possible to find self and to reconstruct one' s life. Home has values for the human that is insatiably after excellence. Home is the first place in which humans grow and nurture their personalities. Home should follow a prototype that provides for all human needs. The design and architecture of home is the most influential architecture of all types that affects the psychological, physical and intellectual health of the human settlers. The quality of human life is highly dependent on the quality of habitation and environment. Research on the relation between satisfaction of the habitation and the social and physical aspects of the dwellings has been in progress since 1970s. Satisfaction of the habitation is directly related to the real needs of human individuals. Bardo and Hughey (1984), Canter and Rees (1982) and Morrissy and Handal (1981) suggested that the satisfaction of home can be improved if the gap between needs and requirements becomes narrower. There is a strong link between home properties and satisfaction of home (Ge & Hokao, 2006). A significant aspect of the properties is associated with the design of the homes that defined as physical and objective properties. These objective properties along with properties of subjective essence are equally important in satisfaction. Given the human needs and the requirements for a proper habitation, the need for home can be discussed in three distinct categories i.e. material needs, non-material needs and moral needs. It is worth to note that the first category of needs i.e. material needs are those needs which are directly associated with the primary needs of humans. The non-material and moral needs, on the other hand, can be thought of the needs which encompass human aspirations and expectations that individuals have of an ideal home.

Material needs: A home should provide shelter to protect human against natural disasters and to offer sufficient spaces with proper shapes and extends to enable physical actions like eating, sleeping and resting. Human is driven by a need to survival and physical security to find secured shelters to rest in.

The functional properties of home are defined in material terms. These are the properties that characterise functional and economic aspects of habitation (SIRGY, 2005: 331). Houses are characterised by their physical properties such as number of spaces, structural strength, sanitary and infrastructural constructs, constructional materials and access to educational, commercial and medical services. Maintenance of these material properties is also another important material aspect of houses, which may encompass a set of practices to:

- Fortification
- Climatic measures
- Position and access
- Number and sizes of spaces
- Service and maintenance.

Non-material needs: Part of human needs has non-material nature and reflects intellectual, psychological, social and cultural aspects of human. The need for attachment and connection, respect and esteem fall under this category. Providing a place that satisfies these needs is another function of home. Meeting these needs can provide an ideal environment for a convincing life.

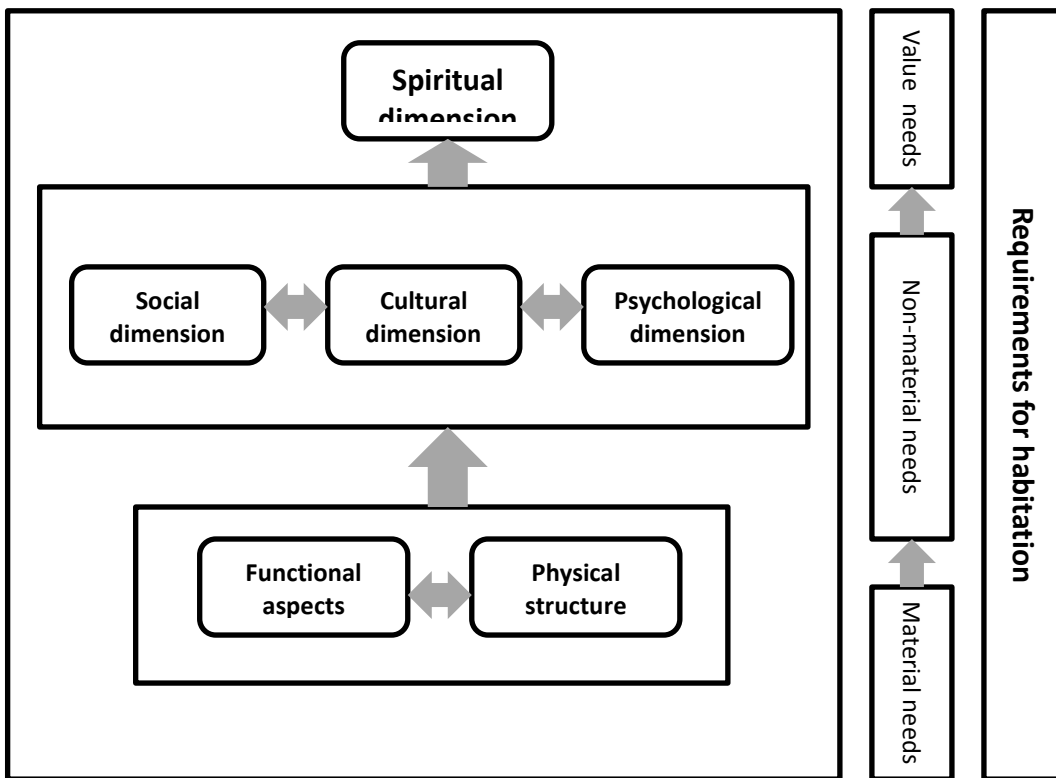
Psychological aspects of home: The need for identity, self-attachment and self-respect fall under this category. Environment affects the psychological state of human mind. Given that home is an environment wherein individuals spend most part of their life, the so called non-material properties of home can significantly affect the inhabitants.

Social and cultural aspects of home: Social aspects include the need to establish and maintain relations with others and to respect others. Research in this field has demonstrated that the design and form of houses reflect social and cultural norms and conventions. Our relations and interactions with others, our common norms and our need to secure personal boundaries and independence determine the way we build our homes.

Value needs: The value dimension of habitation is closely associated with the human' s intellectual needs. It reflects the intellectual and meta-cognitive aspects of the need for self-actualisation. The cognitive needs (i.e. to understand concepts and values) shape the value aspect of homes and are equally important along with the physical and psychological needs in the design of houses. The ultimate form of homes is influenced by hidden intellectual concepts. Similarly, the intellectual functions of a home is much important than its structural functions. A home gains utility when it is consistently built upon the value aspects of the human needs and eventually helps inhabitants to develop their intellectual life. The need for habitation can take a hierarchical scheme similar to the hierarchy of human needs, which is demonstrated in Table 1.

Based on this hierarchy, the material needs are primary needs of human inhabitants and hence take on the first level. The psychological, social, cultural are the non-material needs in the second level. Spiritual needs are value aspects that take on higher levels of the hierarchy accordingly. This hierarchy reflects on the importance and values of needs and the value needs are dominant in this respect. A typical example of this claim is the traditional houses in which decoration and the sense of royalty outweigh the need for light catching structures and as a result of this, colourful windows with small apertures are normally located on top of the traditional buildings to induce a sense of loyalty and luxury. What is of utmost importance in this categorised system needs is that all needs should be in harmony when designing a home. The hierarchical system that is described through the preceding lines, is developed mainly to enable understanding of the importance of each category of needs with respect to other categories. Akin to an individual human that needs to retain a harmony in his needs, a home needs to be build based on a harmonious configuration of all aspects of human needs for space and dwelling.

Table 1: Relation of Habitation of needs



6.4 THE ELEMENT OF TRUTH- SEEKING

The man, intrinsically, tends to figure out the surrounding truths. This tendency was the motive to found sciences throughout history and it accompanies him from birth to death, which persuades him to discover the truth. Naturally, human tends to find visionary perfection. Those who keep this sense alive can reach a phase to enjoy discovering the truth more than anything else.

On-going and traditional perception of “truth” is that they consider the truth as agreement between mental meaning and external occurrence, in a way that mental meaning (imagination or justification) defines the external occurrence. Many philosophers such as Aristotle as well as Muslim philosophers following Aristotle have stipulated this meaning of “truth” , which is only one meaning. In fact, this is a vulgar meaning of truth that has been depreciated to “verity” (Bidhendi, 2002), which implies limiting truth within a logical and rational system. While refusing this vision, Heidegger believes that “logic, which is itself understood by realisation (truth), overshadows it because it exclusively confines truth to “conformity of the thought with the thought itself or to the truth” (Davari, 2003). Heidegger refers the truth to the issue of existence and human relation to existence, who regards truth as nothing but discovery of existence and identification of the unknowns.

Mulla-Sadra also refusing truth as logic states that “truth is defined in combination with existence and “logical truth” as conformity included in the frame of terms and concepts are considered a shell of “genuine truth” and the sketchiest meaning. Mulla-Sadra names ultimate truth as “The end of truth” and believes that “The end of truth is unique and its unity is of a type not. On this basis, everything has a truth and every truth contains another one leading to the end of truth as the root of all objects (Bidhendi, 2002). It is noteworthy that in Islamic theosophy affected by theological principals, “truth” meaning “discovery of existence” has never been forgotten.

The man due to his nature and position is capable to explore the symbols and extend his existence. Truth-seeking of human is resulting from such a potential, which finds a more extensive meaning and gives him a talent beyond wisdoms and insights in certain periods. In general, this capability enables passage of time and change of ages. With respect to things said about the reality of human, his position as a perfect creature and as caliph of God, the truth can be defined as achieving the horizon of understanding a perfect human. A man reaches the truth when he can achieve the horizon of a perfect human. That is, his perceptions and observations become those of a perfect human. Humanity and humane perfection necessitates that he should search for truths and understand them. Logical truth results in formation and promotion of sciences, which in case of reaching an ultimate truth makes man blissful.

The ultimate goal is achieving the ultimate truth. Nasr describes passing and reaching the truth as follows: “the universe is not a screen, on which divine names and characters are reflected, but it is like a crypt where the man should pass to achieve that “truth” , which is beyond universal phenomena. The human-being is not capable to contemplate about the existence unless he can pass it and go far beyond it” . (Nasr, 1989). God, is the true existence and the rest is his appearance. If one could only see God’ s appearance among all externalities and did not see creational aspects of creatures, he has certainly found visionary unity of existence (Shirzad, 2008). Some scientists have obtained faith through science and some have been deviated and called the nature as the ultimate truth. The ultimate goal of understanding the truth is passing from appearance and reaching the essence of the truth that is absolute truth.

6.5 HOW TRUTH-SEEKING APPEARS AT HOUSE

The motive of discovering the truth lies in human nature. This motive in the first level is in the form of tendency to attain knowledge resulting in scientific developments which occur momentarily. This element does not stop at this level and the next level leads human to a real truth which implies why he is created. When science is valuable for questioning about perfection and existential ultimate of man, raising the power of understanding truth is also valuable. The more capable humane wisdom is for understanding the truths, it can identify destination, path and obstacles in a better way and it can pave the ground to reach perfection.

Truth-seeking, in the first level reminds of scientific values, which enable a life with further welfare and convenience from a material viewpoint, and they can meet man’ s physical needs. A true house as a solid and strong structure adapted to climate changes is a visual symbol of increased science and technology in housing construction. A house constructed according to state of the art technologies displays human abilities. During levels of truth, the final goal is to reach an ultimate truth, for which only house can provide necessary background. A true house is one which has the ideal conditions for contemplation and concentration and can help the seeker reach the truth.

6.5.1 A real home

Truth is what is actually seen throughout the universe. Truth is demonstrable through logics and arguments, and there is no doubt in its existence. The human-beings are living in world of truth. The man can create his true world by realising and understanding the realities. A true house is one which is actually observable and analysable. Increasing the facilities at houses is among mankind’ s concerns, which originates from construction of the first house. Construction of strong and optimised houses is the truth of houses built across the world every day.

6.5.1.1 Fortification

Expansion of sciences and application of modern technologies are inevitable factors for constructing fortified buildings. Construction of statically resistant a house, which resist natural events and provide a safe environment for living, is rooted in truth the seeking element. This intent appears in the form of using construction techniques and modern materials, which are stronger and more applicable. Newest technologies in construction sector results in statistically stronger buildings. Quality of construction, technical calculations and usage of appropriate and stable materials relates to technical aspects. Formation of skyscrapers and giant building with the aid of advanced technologies is intended to satisfy the need to achieve perfection. The man can obtain whatever once he dreamed of through increasing his knowledge. Construction technologies enable establishing strong buildings in desirable dimensions and sizes feasible.

Mono-dimensional view of construction technology has negative consequences. Prefabrication in architecture and industrialisation of constructed spaces are among these consequences. In this viewpoint, a house is an industrial product, which is logically justified after increase of the need for residential settlements following the urban sprawls resulting in typical and identical houses without considering the residents' requests. Structure and construction technologies can create fortified buildings at shortest time. These structures guarantee safe living conditions.

6.5.1.2 Optimisation

Consideration of environmental conditions for an architecture adapted to climate changes with minimal energy consumption requires thoughtful solutions, which have gained significant advancements as a result of increase in human knowledge and science. Climatic solutions in housing construction include sunlight orientation, wind direction, places of opening lights, direction of establishment, type of materials, opening dimensions, paints, space hierarchy, open to close space ratio, etc. as well as adding elements with climatic aspects and a building morphology in adaptation with climate changes and maximum consumption of solar and other renewable energies. Usage of natural energies in a building leads to saving of fuel consumption and more importantly to further wellbeing together with protection of the environment.

In the past, the man lived in synchronisation with the nature and reasonably employed environmental factors making a balanced link to nature in a way that each natural factor played a positive role in creating a favourable space. Utilisation of natural energies is carried out via coordinating the synthesised environment with nature. Scientific development started following industrial development and modern humanist thoughts became nature-fighting. As a result, after environmental crisis and criticisms of this thought, a house built by local and natural materials and minimal energy consumption was regarded a value. Afterwards, knowledge prepared the background for such a house.

6.5.2 A true home

A true home is a real home, which reveals the truth- a reality which exhibits the ultimate goal of living. In this situation, house is the only tool to point to the truth and serves as a reflector. Truth can be found by thinking and speculating, thus a house where speculation and contemplation about nature is possible, is a true one.

6.5.2.1 Thinking potential

Thinking is one the greatest worships and without it man can reach any material and spiritual development. In fact, thinking is a result of human' s humanity, which distinguishes him other

creatures. Thinking has some ranks depending on who is thinking and what is he/she thinking about (Mazaheri,2009).

God has stipulated the reasons why Quran was revealed in some verses (Nahl, 44). We revealed Quran unto the Remembrance that though explain to mankind that which hath been revealed for them, and that haply they may reflect” . Emphasising on the importance of thinking the Prophet Muhammad stated: “one hour of thinking is more valuable than one year, only one who can particularly endow himself with cognition and theism.”

The main level that can be taken into consideration as the ultimate element of truth-seeking in human nature is looking for a real truth. It is truth, which requires thinking and speculation. Spencer describes it this way:

“To achieve this truth, we need to think for many years, not acting, not arguing, not computing, not behaving chaotically, not reading, not suggesting. The only thing a person needs to know is mental analysis.” (Oliver,1987)

In other words, thinking is way to approach God and reach blissfulness. In order to think and concentrate in a residential area a quiet place is needed a peaceful and silent atmosphere where deep thinking is made possible. A house is a place to relax so that the man can think deeply and to attain mental and spiritual self-awareness. This space by directing the man to his interior seeks to find a place to provide him with peace and pave the way for him to experience levels of perfection look for truth. Space polarity and concentration-creating order are principles for spiritualising the architecture seen in traditional architecture resulted from factor such as geometry, spatial proportions, unity and consolidation, spatial classification, hierarchy, symmetry and emphasis on visual focus and centrality.

6.5.2.2 *Contemplation about nature*

Thinking and speculation about nature is one way to find truth. Identification of nature is valuable when it guide the man a hidden truth. Avicenna has thought about this and writes: “research in the natural world is not only research on phenomena and finding s series of relations, but it is a research on phenomenon and appearance” (Nasr, 1989).

In this perspective, nature is a code and symbol for real true which can be a medium to find God. In Holy Quran everything in the world and all existing objects are “ the symbols of God “ (Mohaghegh Damadi, 2001). In many verses (Goran), God invites man to think about nature as in Al-Raad: 3 “And He it is Who spread out the earth and placed therein firm hills and flowing streams, and of all fruits He placed therein two spouses (male and female) and in Al-Fussilat: 53. The universe is a sign of God. Therefore, Nasr writes: “the nature itself is a divine inspiration accompanied by metaphysics and it has a particular style of worship. “(Nasr, 1989).

Intuitional understanding is described by Nadimi as follows:

“sensible nature and its hidden and surprising geometry, as the decoder of archetypes is source of inspiration for Muslim architect. He/she becomes an artist by observing these codes and feeling them from depth of his/her soul and flying in world of dreams. The inspiration of a naturalist architecture is that of its hidden role, which exhibits unitary geometry far beyond its multiplicities and diversities” (Nadimi, 1999).

The role of nature in a settlement or a house is played via application of natural elements such as trees, water, so on like traditional houses in which a terrestrial paradise is created with the aid of trees, water and pond within the yard (Figure 2). This is sometimes constructed by combining interior spaces with other nature-oriented landscapes (sky, mountains, etc.) (Figure 3).



Figure 2: tabatabaye house in kashan-Iran(Ref: <http://www.rayahb.com>)



Figure 3: Oshtobin Village- Iran

6.6 DISCUSSION AND CONCLUSION

The element of truth seeking has its root in the nature of human being and reflects on the human aspirations. This element in this sense provides a common language that guides all humans equally to transcend to a moral stage of excellence. Truth seeking enriches human artefacts with durability and persistence. Home is one of the human artefacts that are highly affected by human needs for habitation. Reflection of the element of truth seeking in the design and functions of homes gives home non-material dimensions and values that persist over time and never fade away.

This article described the element of truth seeking and argued that proper understanding and incorporation of this element in the design and construction of homes can reveal real aspects of an idea home. The article holds that traditional architecture best reflects such a harmonious combination of the elements of sustainability and the mastery of architectural design. It is also argued that a real home is fundamentally built to meet material needs for habitation means, while an ideal home is substantially a manifestation of moral human needs. A real home is a home which is strong and optimised, while a real home is a home that provides opportunities to contemplate and discover the ultimate truth.

It is important to take into consideration that the intrinsic needs of human for a morally enriched home is a core element of social and cultural sustainability at homes. A desirable quality of life can be achieved by making homes morally sustainable and a place to intellectually grow and develop through establishment of a deep relation between architectural design and phenomenology of human needs.

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7 Optimised Energy utilisation solutions in Iranian architecture: Case study:

Hoze Khaneh of Qajar Era in Tabriz

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Abstract: Consumption of non-renewable energies increased promptly due to global industrialisation development and created some global issues. Hence, energy saving and sustainable development are the most important international topics, accordingly, architects and designers have always tried to develop some appropriate models for energy consumption. Sustainable development has been more popularised in the mid- seventies to satisfy current needs of humanity by focusing on clean environment without jeopardising the needs of future generations and maintenance of clean global environment. This paper is going to develop some compatible patterns and recommend some solutions for energy conservation and optimised energy solutions in Iranian traditional architecture. It seems that Iranian architects and designers have mainly tried to protect the natural environment so; they have tried to willingly or unwittingly utilise components of sustainable architecture. This survey and library based paper is trying to find components of sustainable architecture and conform it to Iranian traditional architecture. Epochal- interpretive techniques have been used to test the hypothesis, thus the inductive method is chosen to follow up a case study in Tabriz. The paper concludes that Iranian architects have developed some strategies and solutions to preserve sustainable architecture in history.

Keywords: Sustainable Development, Iranian Traditional Architecture, Green Design, Hoze Khaneh¹

¹ The Hoze Khaneh was used as a summer chamber during the Qajar era to rest in summer, to preserve meat and other perishable materials

7.1 INTRODUCTION

Industrial cities needed employees, and relative improvement of health environmental issues was due to more construction of urban areas. Then, consumption rate of non-renewable energy resources increased quickly and people faced with some problems including shortage of non-renewable energy resources, environment pollution and so on, thus concerned architects and designers decided to find some solutions and propose some creative ideas for facing such problems; they decided to develop environmental friendly construction where consumption of non-renewable energy resources is minimised.

Environmental issues and optimised energy usage components were focused more, they decided to recycle and use non-fossil energies today, they are named renewable components and sustainable architecture was developed gradually. Conformed components with remained architecture works of the Iranian architects are based on environment cognition where sustainable architecture is utilised. This paper is going to find historical techniques and principles used by Iranian architectures to propose some solutions modern based on experiences of the past architects, it seems that traditional architect has willingly and unwittingly used principles of sustainable energy to design environment friendly constructions by focusing on limited energy resources.

7.2 RESEARCH METHOD

This paper is mainly investigating to know how domestic Iranian architecture has developed some solutions for optimised usage of energy, the thesis is trying to prove that Iranian architects have identified natural elements and has recommended some effective solutions for sustainable architecture in Iran. Library resources and surveys have been utilised for conclusion. Historical- interpretative method has been used to test the hypothesis and answer the investigation question through deductive method, Tabriz historical Hoze Khaneh is reviewed as a case study.

7.3 SUSTAINABLE DEVELOPMENT

The word sustainable development created in mid-seventies, it has been used more after oil crisis in 1973. Finally, Rio Conference in 1992 the topics of sustainable development approached to their tip-top. Where a resolution issued to develop solutions for global sustainable development, world countries were obliged then to follow up the resolution. The most important definition of sustainable development in Rio Conference was that:

“Sustainable development must satisfy human needs in an environment friendly space where the needs and requirements of future generations are taken into consideration too.” (Hatami,Golzari, 1387:37).

Culture, domestic features, gained experiences of the past; utilisation of renewable energies and their replacement with non-renewable ones are the most important topics to be focused more always.

7.3.1 *Principles of green architecture*

Following principles must be observed for a renewable construction or building:

(Qiasvand, 1385:4):

- Energy saving
- Climate coordination
- Reduced consumption of new resources
- Satisfied needs of the residents
- Coordination with site
- Total-orientation

7.3.2 Energy and sustainable architecture

Energy resources, utilisation of renewable energies and non-utilisation of non-deniable energies have permanently been focused in sustainable development and some different solutions have been proposed. Location cognition, relationship with environment, cognition of natural processes as well as the impact on environment must be considered more in designing. Location cognition: sustainable designing needs to identify location; Directed Light toward the building, is a helpful designing aid for environment preservation. Effective direction of the building facilitates less energy consumption due to the directed natural light into the building, natural heat resource is available and facilitates more accessibility to natural energy.

Relationship with environment: urban or rural designing processes need to be coordinated with environment, they must develop an environment friendly space where the natural environment is less damaged; less energy is consumed to produce renewable materials. Cognition of the natural processes eliminates environment wastes. In other words, cycle of natural systems renews nature based on environment friendly designing process. Cognition of environmental impacts: environment impacts are identified based on site assessment and evaluation. Negative environmental impacts are reduced more with more usage of efficient renewable energy, structures technology and selection of renewable materials; (www.miarch.com/www.greenbuilder.com).

7.3.3 Implemented Climate techniques in construction of Iranian houses

Implemented climate techniques in construction of Iranian houses are summarised below:

7.3.3.1 Orientation

A feature of traditional house is orientation, the experienced traditional architects have utilised climate features, direction of light, wind, and other elements based on different climate conditions in Iran. (Memarian, 1390:135). In traditional Iranian buildings, three sides are focused to locate construction based on (northeast-southwest) Isfahani (North West - South East) Kermani (east-west) directions. In Tehran, Yazd, Jahrom, and Tabriz the buildings are directed towards northeast-southwest. In Isfahan, Estakhr, Shiraz and so forth the buildings are directed towards North West - South East and finally, in Hamadan, Kerman, western Azerbaijan, Khoy and so on the buildings are directed toward east-west. (Pirnia, 1382:156). These orientations are the best ones to locate the building based on climate conditions, its dimension, number of openings in each side for optimum use of sun and wind as natural elements for light and ventilation,

thus, less energy is used and more saved.

Table1: Principles of Sustainable Architecture

Principles of sustainable architecture	Definition	Features
Energy Conservation	Minimum Fossil fuel requirement	Utilisation of renewable energies and their replacement with non-renewable energies
Work on climate	Climate usage and utilisation of local energy resources	Designing of building, its foundation, internal areas- and proper insulation
utilisation reduction of new resources	Every building is a resource for other structures	Recurrent usage of the resources through recycled materials, or recycled spaces, using a building for other purposes and with new usages
Respecting users	Respecting all common resources to construct a building – users’ positive interference in designing and construction process	Trying to reduce pollutions due to global climate change, destruction of Ozon layer- focusing on safe and sound materials, construction and building processes, for workers, users and all human communities including utilisation exemption of the CFCs
Respecting precinct	Building and surrounding enclosure must be coordinated so that the damage is prevented	energy resources usage providence – pollution prevention-coordination between consumers, users, and consumers – designing so that the destructed site is easily reclaimed
Total-Orientation	Compatibility principles must be observed	Designing based on the above mentioned principles

7.3.3.2 Sinking into the soil

Constructing underground spaces facilitates more thermal capacity utilisation in different season, and another climate based technique, spaces such as Caspian Sea border are exempted to develop such constructions for high soil moisture. (Parvardinejad, Zandieh, 1389:9).

7.3.3.3 Green area

Gardens and low water consumption trees provide shadow, they are used in production and natural elegance depends on them, also, they compensate humidity. These green areas attract sun radiations, eliminate light reflection and unwanted heat (Asadpoor, 1385:70) these trees are sometimes air-pockets or windward sometimes. (Parvardinejad , Zandieh, 1389:9).

7.3.3.4 Application of suitable materials

Climate based domestic materials with effective thermal capacity are used in Iranian residential architecture. Not only suitable materials are used for every climate conditions but also, transportation costs and other secondary costs are eliminated. (Parvardinejad , Zandieh, 1389:9).

7.3.3.5 *Insulation in Traditional architecture*

Another feature of the traditional house is how to prevent heat, cold and annoying sun radiations into the internal space; thus, insulation is used to facilitate effective utilisation of heating and cooling systems. Insulation is widely used based on two peculiar methods and it is very important in architecture, the mentioned methods are:

A. Developing two layers:

Creating an empty space between canopy and roof of the building. Air between the two layers is named shelter it prevents heat and cool transfer. Canos are small vaults that cover the two sides -by -side domes two provide a flat space. An arched canopy is flattened through Cano, also, it is used to develop the second floor, vaults and domes became flat in this way, belvedere was utilised too. (Memarian, 1390:138).

B. Radiation prevention:

Old buildings were made so that direct sun radiation was prevented. Using 6-15cm wide fine radiation blades or louvers, the louvers were installed on top of doorway or window. Horizontal ones named canopy. Vertical louvers were made of plaster or brick with 60-70 cm wide and 10-15mm thickness. Accordingly, the doorways or windows are not directly contacted with sun radiation. Horizontal louvers are made of circular apertures named Goljam . Doorways are covered with Kharak Poosh.

Louver, Goljam and Kharak Poosh were used to prevent direct sun radiation. Moreover, doors and windows were made of colorful glass to prevent direct sun radiation. Sashes were the most beautiful wooden windows and doors; they were decorated with small circular wooden frames and they installed peculiar glasses on the sashes.

7.3.3.6 *Water and traditional architecture*

There was a water pool amid the yard , there were cellars too, water was used in Hoze Khaneh to provide fresh air , there was an elegant scenery due to waterfall, jet of water to instill a clam sensation in residential houses(Parvardinejad, Zandieh, 1389:10).

7.3.4 *Elements and climate spaces of Iranian houses*

7.3.4.1 *Cella*

It is the same as a winter building . Belvedere amid the house or Hoze Khaneh or every building used in summer is named cellar too. Then only basement was named cellar. There are various cellars. Two storey basements are constructed in Khuzestan province. a bedchamber and Shabadan , a very depth structure beneath the bedchamber that is very cool and it is used in summer. Shabadan is deeper than the bedchamber, usually, its canopy is made so that its floor is higher than the Myansara, a stairway links Shabadan to Myansara. (Memarian, 1390:165).

7.3.4.2 *Hoze Khaneh*

It is located at basement, there is a pool used to cool the building in summer. In fact, it is a hut equipped with water jets (www.loghatname.com). There are many different spaces in Kashan named Hoze Khaneh, they are located at the corners of the ground floor. They are decorated with plaster material or Simgol¹ a kind of Yazdi Category

decorations. Instead Tabriz people develop such decorations with painted bricks and currently peculiar complex applications.

The most important implemented patterns is torn abdominal shaped Hoze Khaneh. Wind -catchers are linked to this space where wind passes over the pool-water and a fresh air is entered into the building. Cities such as Tabriz do not have hut, but the Hoze Khaneh is beneath main space of the winter -stay space equipped with doors and windows. (Memarian, 1387:1379). Iranian house has a pool under dome , such houses are cool, and humid, where various images are created, this complex is named Hoze Khaneh. (Haieri Mazandarani, 1388:129).

7.3.4.3 Courtyard

It is an enclosure based on Dehkhoda dictionary and the house is surrounded or enclosed by the yard. Iranian people use courtyards in different ways mentioned below:

- To develop a merry green environment, it is also used as an artificial ventilator where suitable winds are passed (Memarian, 1387:13).
- Mixed clay, Dune and straw particles

7.3.4.4 Sunken garden

It is amid the central courtyard, it is sunken to the basement too. Ancient Iranians tried to provide required soil to produce brick through sunken garden; also, it facilitated residents' availability of a building to subterranean water. Usually, sunken garden includes flowing water filling central pool, the overflow has been used by other houses. These courtyards are smaller and lower, where cool space, moisture of plants and cool water are utilised in a fresher climate area than that of the courtyard. (Parsi, 1387).

7.3.5 Effective utilisation of Energy

Regarding to the past times when non-renewable fossil energies were not used may facilitate accessibility to the very valuable clean energies. All designing processes of a building have been implemented precisely and simultaneously that are pinpointing success secrets and delicacy of a consolidated building. Also, continual training trend, has integrated experienced based regional architecture.

7.3.6 Climate study of Tabriz city

In Tabriz, winters are very cold but summers are hot and dry. So, the building must be conformed to climate conditions so that, it can absorb maximum heat but in summer the minimum. (Khodabakhshi, Mofidi, :612). Features of vernacular architecture in Tabriz are mostly similar to interior – oriented architecture of hot and dry area; But with some necessary differences of cold climate.

- Space structure of the building: In Tabriz, buildings are oriented towards northern and southern directions to prevent cold weather in winter, all windows are equipped with double glazed glasses, mainly, there is an internal and external window. (Khodabakhshi, Mofidi: 612)

- Effect of air –flow and sunlight : buildings are constructed so that maximum and minimum heat is used in winter and summer respectively. Hence, long southern and northern walls are equipped with main openings. They install double glazed windows to prevent heat in winter. Accordingly, it is necessary for air to circulate into the building; but large sashes are installed on northern walls to pass more light into the building.
- Building or construction materials: in Tabriz the walls are built very thick , they are made of brick and mixed straw and are used to cover the rooftops.

7.4 HOZE KHANEH_IN THE HOUSE OF TABRIZ

Old houses had a main and important space at the northern side of the main building where a pool was located and it was used as a rest room, reservoir for perishable foods such as meat and other products such as cereals. Sothern and northern Crossway porch links the houses. Hoze Khaneh has its openings towards the porch (houses of Haj Sheik Alavi, Mashrotiat, Ghadaki and savojbolaghi). Hoze Khaneh is located at bottom floor of Tanbi (houses of Salmasi, Haj Sheikh Alavi, Southern Mojtahedi, Ghadaki, Heidarzadeh, Savojbolaghi, Amirnezam, Nishabouri, and Sehati). Only in Mashrotiat house, Hoze Khaneh is located at ground floor. other houses, either do not have Hoze Khaneh or it is not located at the central axis such as (Nishabouri' s house) or it is transformed such as (Sehati house). All reviewed samples have not been alongside the accessory axis. (Keynezhad, 1389:17).

(1 In old houses, Tanbi was the main space but later it became an important space in current houses which is alongside main axis at northern part of the building, it was mainly used as guest or reception room).

7.4.1 Studying features, element Hoze Khaneh s and implemented solutions in historical houses at Qajar era in Tabriz

Table.2 illustrates the different roles of Hoze Khaneh in historical houses in Tabriz in Qajar Era and Table 3 explains how this architectural element leveraged sustainability in those buildings.

Table.2: Studying space of Hoze Khaneh in Tabriz historical houses in Qajar Era


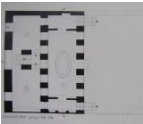
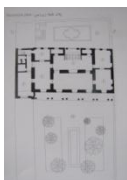
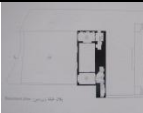

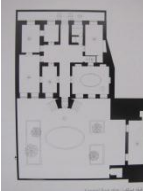
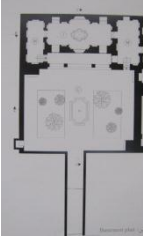
Name of house	Plan	current use	skunked into soil	skunked the garden	green area	southern orientation	insulation	roofing development strategies	pool	materials	building shape	directed light towards south
Qadaki		faculty of architecture	✓	✓	✓	✓	✓	using upper stories	✓	brick and stone	rectangular	✓
Sehati		Moharram museum	✓	✓	✓	✓	✓	using upper stories	✓	brick and stone	rectangular	✓
Sharbat Oqloo		Iranshenaci museum	✓	✓	✓	✓	✓	using upper stories	✓	brick and stone	rectangular	✓
Mojtahedi		under restoration	✓	✓	✓	✓	✓	using upper stories	✓	brick and stone	rectangular	✓
Kouzeh kanani(Mashrote)		Mashrotiat museum	✓	✓	✓	✓	✓	using upper stories	✓	brick and stone	rectangular	✓
Nishabouri (Mahde Quran)		Mahde Quran	✓	✓	✓	✓	✓	using upper stories	✓	brick and stone	rectangular	✓
Alavi		museum	✓	✓	✓	✓	✓	using upper stories	✓	brick and stone	rectangular	✓

Table3: Conformed architecture features of Hoze Khaneh with sustainable architecture principles

Principles of Sustainable architecture In Hoze Khaneh	Proposed solutions for more energy saving	Features	Implemented techniques in Hoze Khaneh
Save energy	Utilizing renewable energies and controlling entering and exiting energy to the building	Minimum Fossil fuels are needed	Sinking into the soil ,Creating green space, to absorb unwanted heat , skunked garden, effective direction
Climate coordination	Correct insulation, and effective direction of the building	Climate and local energy resources are used	Insulation and using of thick walls, covering the roof with two layers, using upper floor of the Hoze Khaneh
Reducing usage of new resources	Usage form of the buildings is changed , the materials are used to construct new buildings	Minimum resources are used the materials are recycled when the building was destructed.	Potential of usage change in current era: Museum, Faculty of architecture and so forth
Residents' needs are satisfied	CFCs are not used to prevent environment pollution where the user interfere in designing process	All consumers are respected and their needs satisfied, and	People friendly architect who knows their needs and considers their needs in daily life, when he or she decides to design
Respecting to precinct	Less pollution, less consumption, conformed colour, texture and kind of conformable material with climate	the site design is conformed with the courtyard	Using domestic materials with effective thermal capacity
Total -Orientation	Maximum use of the above items in designing	All above principles are conformed	Implementing all mentioned items for cold and mountaineer climate based design in Tabriz for optimum environmental utilisation as well as utilisation of renewable energy

7.5 SUMMARISED CONCLUSION

Regarding to the following definitions and principles of sustainable energy and its conformability with Hoze Khaneh spaces, it is concluded that Hoze Khaneh architecture is categorised as sustainable building design:

- Energy saving and minimum need to fossil fuels by sinking into the soil, creating green area , effective building orientation, and developing depth garden surrounding the Hoze Khaneh.

- Conformation and coordination with cold climate of Tabriz city, through covering the roof with two layers and peculiar insulation.
- New flexibility for the use in form of educational and cultural sites, etc.
- Utilising domestic materials with effective thermal capacity , less pollution, and high renewable and recyclable materials in the environment.
- Renewable architecture principles are observed resulted in their continuance in various historical post periods.

Regarding the studies and witnessed high effects of observed simple principles to provide desirable space of Hoze Khaneh , such spaces do not need fossil energies to adjust internal temperature of the building, hence, it is concluded that since old buildings constructed by our ancestors have been very effective without their need to renewable energies, and the traditional architectures located at cold and hot regions have found very effective climate responses for designing buildings; furthermore, this study is investigating the post construction records to develop simple strategies for building construction to reduce utilisation of fossil fuels and to preserve clean environment .

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8 Fostering energy efficiency dynamics through EX-ANTE strategic NICHE managemEnt: the uk perspective.

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Abstract: The United Kingdom building sector has been challenged to retrofit a huge stock of existing buildings in order to increase its adaptive capacity for climate change impacts. Addressing such challenges will require systematic structural changes in both, socio-technical and socio-political infrastructure. A numbers of studies have suggested the approach of strategic niche management of transition for sustainable technological regimes. Accordingly, any such transition would follow processes of early stages of niche formation; creation of policy mechanism required to harness the niches; niche expansion into incumbent regime; and the regime fully transformed into sustainable technological regime. Following this, the UK Government has introduced a raft of initiatives; one of which is “Green Deal” to enable buildings to become energy efficient through retrofit technologies, ultimately contributing towards the national goal of achieving 80% reduction in carbon emission by 2050. This paper serves three purposes. First, the paper introduces multi-level socio-technical system for construction/retrofitting in building industry. Second, the ex-ante strategic niche management approach has been used to analyse the dynamic of “Green Deal” initiative. Thereby the paper would critically assess technological, organisational and institutional reforms undertaken for the initiative in the processes for sustainable technological transition. Third, the paper would contribute towards strategic niche management literature which lacks in practical examples of using it as an ex-ante tool for niche building and regime transition.

Keywords: Socio-Technical Transition, Strategic Niche Management, Mitigation and Adaptation, “Green Deal”, Retrofit Technologies, Energy Efficiency.

8.1 INTRODUCTION

Anthropogenic activities resulting from technological and medical advances; and the consequential growth of population, agriculture and animal husbandry since last two centuries has led to exponential increase in carbon-dioxide concentration (Turner II *et al.*, 1990; Crutzen, 2000; McNeill, 2001; IPCC, 2001; Crutzen, 2002; IPCC, 2007). Particles of other gases such as methane, halocarbons, nitrous oxide and soot have also increased due to the burning of fossil-fuel, large-scale land-use changes, different energy uses, combustion and manufacturing processes. These all have collectively intensified climate change which would need careful mitigation and adaptation processes to accomplish societal sustainable development (Wilbanks *et al.*, 2003; Wilbanks, 2005; Wilbanks *et al.*, 2007; Bierbaum *et al.*, 2007; IPCC, 2007; Klein *et al.*, 2007a; Klein *et al.*, 2007b; Holdren, 2008; Moser, 2012).

Recognising the responsibility of tackling climate change, the international community has set targets to reduce carbon emissions depending upon their capacity (UNEP, 2009). Consequently, the United Kingdom (UK) has set ambitious targets to reduce greenhouse gas (GHG) emissions by 80% by 2050 compared to the base year 1990 (DECC, 2009). Given this, buildings would need to be zero emissions by 2050 (DECC, 2010). UK has large existing building stock constructed ostensibly in 20th century and 87% will still exist in 2050. These buildings are heated and equipped with traditional

energy intensive technology and appliances which use twice the energy used in Nordic countries (Lapillonne and Pollier, 2007). They account for 37% of the UK emissions. Also, it is posited that these buildings may not offer comfort, safety and resource efficiency to the users' expectations in coming years; instead their use would have unsustainable impacts on societal development. Moreover, the analysis show that the domestic consumers will pay 7.1% lower in 2020 than they would pay without policy interventions in place (DECC, 2011b). Thus energy efficiency plans for buildings are very crucial and retrofitting is required at a massive scale and at a very fast pace (Boardman, 2007; Hunt, 2008; Three Regions Climate Change Group, 2008). Retrofitting in buildings is not a new concept; however, speedy mass retrofitting of all existing buildings to increase energy performance in accordance to the Building Directive (European Union, 2010), in the domestic sector and bringing properties to bands A and B on the Energy Performance Certificates (Op. cit. Boardman, 2007) is certainly a huge challenge.

The UK Coalition Government has announced an initiative to make UK buildings more energy efficient. The initiative, "Green Deal", is a voluntary government policy propelled by an innovative financial mechanism. It allows the consumer to implement energy efficiency measures in the building, recommended by the "Green Deal" assessor, fully or partly financed by the "Green Deal" provider. The 'Golden Rule' associated with the "Green Deal" is that "the financial savings resulting from installing measures must be equal to or greater than the cost of repayment over the term of the "Green Deal" Plan" (DECC, 2011a). It is expected by the government that the "Green Deal" would improve energy efficiency immensely, contributing towards carbon reduction targets (DECC, 2010).

Socio-technical transitions are complex, multi-level, long-term transition processes that change existing, relatively stable, socio-technological regimes to drive the societal development with increased sustainability (Geels, 2002; Geels, 2004; Geels and Schot, 2007; Geels, 2010; Markard and Truffer, 2008; Smith *et al.*, 2010). The number of papers (for example: Schot *et al.*, 1994; Smith *et al.*, 2002; Smith *et al.*, 2005; Elzen and Wieczorek, 2005; Geels, 2005; Kemp and Loorbach, 2006; Hekkert *et al.*, 2007; Van der Laak *et al.*, 2007; Loorbach, 2007) within the remit of *Socio-technical change, transition and management* have analysed the transition process, factors affecting them, actors involved in the process and challenges of governing such transitions to assist the practitioners in facilitating and managing transitions. These studies have used strategic niche management (SNM) and transition management approach to analyse radical sustainable innovations. Mourik and Raven (2006) propose that SNM approach can be used as an ex-ante analytical tool to analyse the performance of state-of-the-art experiments and support project managers and niche developers. But "lack of detailed and practical guidelines for practicing project- and niche builders" have not allowed SNM to play an efficient role in promoting sustainable technologies.

The main aim of the paper is to analyse the dynamics of the "Green Deal", an innovative programme that has been proposed to "foster the building of green technology manufacturing capability in the UK" (The Green New Deal Group, 2012). The "Green Deal" is an interesting case study because over the time, it would bring significant socio-technical change: for example, 14 million energy efficient buildings would be retrofitted with energy saving measures such as increased insulation, smart

meters and renewable energy wherever applicable; reduce costs on energy imports; create employment and stimulate the economy (The Green New Deal Group, 2012). The aim is achieved by introducing socio-technical system for construction/retrofitting in building industry comprising of multi-levels and using SNM to critically assess various reforms undertaken for the initiative to help the niches flourish and contribute towards the transition of sustainable technological regime. The paper would also contribute towards SNM literature which lacks in practical examples (Mourik and Raven, 2006; Healey, 2008; Raven *et al.*, 2010).

The SNM literature has already identified processes responsible for successful transition to sustainable regimes (Kemp *et al.*, 1998; Kemp and Rotmans, 2001; Geels, 2002). Analysing dynamics of the “Green Deal” programme using SNM ex-ante approach would help to critically assess the reforms undertaken for the programme and guide the practitioners (different actors at different levels) for improved actions. The case study is carried out purely based on documentation which is the primary source of information easily available for any “Green Deal” stakeholder. They include research papers, reports, policy reviews, special group reports, consultation papers and information from websites. Though, the authors acknowledge weaknesses lying with documents such as unintentional bias in selected documents or documents’ authors, and no access to confidential documents. Empirically, the paper will scrutinise the activities related to the “Green Deal” and discuss the existing arrangements to foster green technologies related to high uptake of energy efficiency measures in buildings.

The paper is structured as follows: Section 2 discusses characteristics of strategic niche management. Section 3 introduces construction/retrofitting socio-technical regime and discusses the “Green Deal” *modus operandi*. Section 4 critically assesses whether the innovative financial reform introduced for the “Green Deal” would help the transition of retrofitting incumbent regime into sustainable technological regime. Finally, section 5 concludes with some practical suggestions for the practitioners.

8.2 STRATEGIC NICH MANAGEMENT

Kemp *et al.*, (1998), Hoogma *et al.*, (2002) and Raven (2005) have suggested SNM for the transition of technological innovations into the mainstream. Number of studies (for example, Kemp, 1994; Kemp and Soete, 1992; Rip, 1995; Schot *et al.*, 1994; Schot and Rip, 1996; van den Belt and Rip, 1987) have effectively analysed the socio-technical transition to understand the importance of underlying dynamics and mechanisms responsible for technological transitions. Kemp *et al.* (1998) analysed results of early market introduction of sustainable technologies and identified various factors hampering its widespread growth. They include lack of technical stability, weak regulatory framework; societal preferences and values; lack of demand; incompetent infrastructure for maintenance; and unknown impacts of new technologies. Even so, scholars argue that radical innovations succeed (Winkel, 2002; Correljé and Verbong, 2004; Geels, 2005a; Geels, 2005b) and the transition takes place involving two levels: the ‘socio-technical landscape’ and ‘niches’ (Rip and Kemp, 1998; Geels, 2002; Raven, 2005). The scholars have effectively analysed the success of historical transitions of innovative technologies using SNM and multi-level transition perspectives, emphasising the role of innovative technological niches, diverging from the existing regime, emerging as a new regime and subsequently transformed into

sustainable technological regime (Smith, 2002).

Weber *et al.* (1999) suggests that SNM is instrumental in organising projects of innovative sustainable technologies. They suggest two stage processes and make distinction between experimental projects and niche. The experimental projects are carried out in isolation for interacting, networking and learning process, simultaneously acting as the starting point (first stage) for the development of a niche. Projects when carried out on multiple scales accumulate to form an innovative technological niche (second stage). Niche is the result of more developed experimental interrelated projects in time. Moreover, Leonard (1998) recognises that SNM is particularly advantageous in the early development process of niche formation, especially when there is considerable uncertainty in terms of technological specification and the users' preference (market). It pinpoints that SNM is a market research tool which would help to identify critical information of the users' preferences and technology suitability and assist in developing an absolute design for the potentially radical and sustainable technologies.

Geels and Raven (2006a, 2006b) define that SNM is the valuable tool for practitioners who are managing cluster of interrelated experimental projects, striving to transit innovative technologies into the mainstream. The tool is particularly useful in analysing the actions for management of projects at local niche level rather than management of individual project. It aligns the actions with the local expectations and rules of global niche level, guiding the managers for more consistent actions at local level and making all relevant resources admissible for the development of the niche. The evolutionary interactions of local success with the global targets, contributes towards the formation of a stabilised niche. This encouraged researchers (for example, Hoogma *et al.*, 2002; Schot *et al.*, 1999; Weber *et al.*, 1999; Caniëls and Romijn, 2006; Rotmas and Loorbach, 2006; Loorbach, 2007) to develop a conceptual framework for ex post analysis which enables the practitioner to understand "real life" complexity from "multi-stakeholder approach" (Grablowitz *et al.*, 1998). However, there is very little evidence of using SNM as an ex-ante tool. In order to enhance the use of SNM tool as an ex-ante tool for regime transformation, the case of "Green Deal" is appropriate for a number of reasons. It illustrates the niche formation process at micro-level as a result of successful experimental projects, collectively contributing towards the formation of a sociotechnical landscape of energy efficient building technology. The dynamics of the "Green Deal" well illustrates that regime solutions are appropriate for societal challenges. Though some (practitioners?) doubt if the "Green Deal" would be able to bring about accepted stimulation and effective policy and practices integration for these actions at all levels of the regime. The prominence of the "Green Deal" issue makes it especially appropriate for analysis by sustainability transition managers.

8.3 THE "GREEN DEAL": MODUS OPERANDI

The "Green Deal" niche formation is conceptualised by collection of successful experimental projects, linking innovations within the existing socio-technical regime of building industry. This section will introduce socio-technical regime, multilevel perspective of SNM, discuss experimental projects and innovative financial mechanism attached to the "Green Deal" modus operandi.

8.3.1 Socio-technical regime

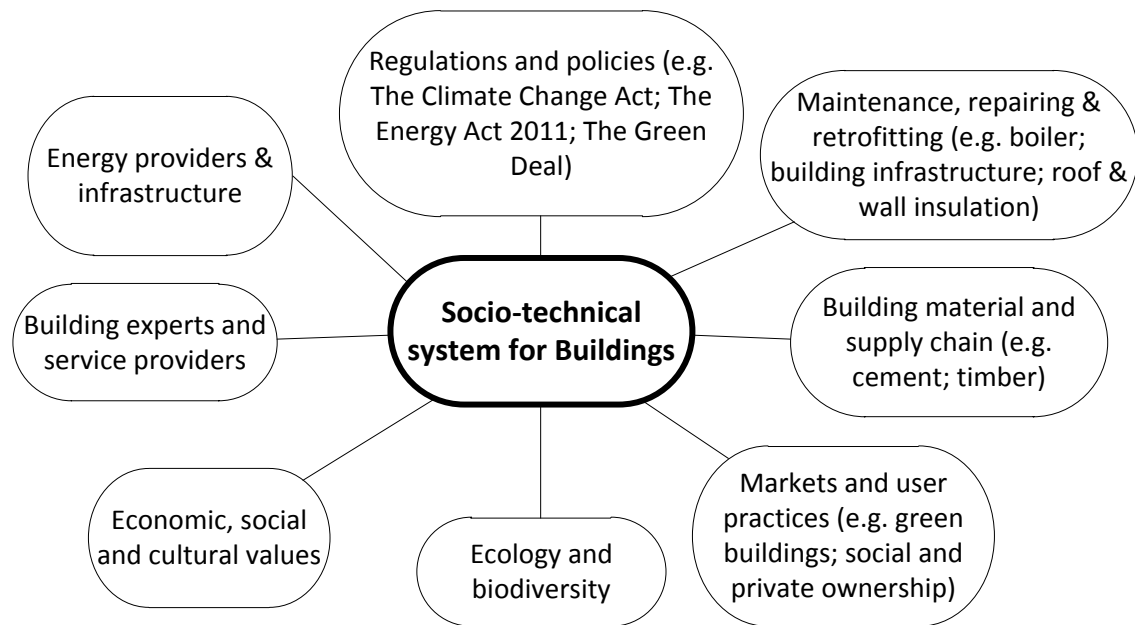


Figure 28: Socio-technical system for Building industry (Adapted from Geels, 2005b)

Socio-technical regime consisting of physical, natural, social, economic, cultural and cognitive attributes (Rip and Kemp, 1998). The regime is a combination of components such as artefacts, material networks, economic system dependent on the artefact, lifestyles adapted to the artefacts, infrastructure and technology, and supply chain created by and for the artefacts. The technical systems of production and distribution when incorporate the components related to the users, they are called socio-technical regime (Geels, 2004). The socio-technical regime of construction/retrofitting in the building industry is shown in Figure 1. Complementarities between components make these systems function; nevertheless these complementarities are equally responsible for making them dynamically rigid, standard, stable, or locked-in (Staudenmaier, 1989; Rycroft and Kash, 2002; Arthur, 1988; Rip and Kemp, 1998; Walker, 2000). Socio-technical systems established in the form of “wider, linked processes” and “embedded with firms and technologies” support societal needs such as housing, mobility, food, communications and so on (Smith *et al.*, 2005; Rip and Kemp, 1998; Geels, 2002a, b). Modern societies are challenged by serious problems such as increasing carbon emissions and effects of climate change. Thus, radical changes and a new technology shift in these socio-technical systems are necessary more than ever (Berkhout, 2002).

The regime constitutes of the environment provided by (1) rules and regulations: for example, Climate Change Act, 2008 and Climate Change Agreement (DECC, 2012); (2) institutional and technological capacities: such as energy efficient heating, ventilation and air conditioning appliances, efficient building fabric material, energy saving lighting and water heating, and appropriate micro-generation technologies (DECC, 2011c); and (3) regime actors: such as Green Deal provider, installers, accredited assessors, approved products suppliers and Energy companies (See Figure 2). Such regimes are the facilitator for the change (Van der Vleuten and Raven, 2006). Moreover, regime members are making conscious efforts to address recognised challenges; and resources and responses are directed towards innovative activities with high coordination to solve the problem.

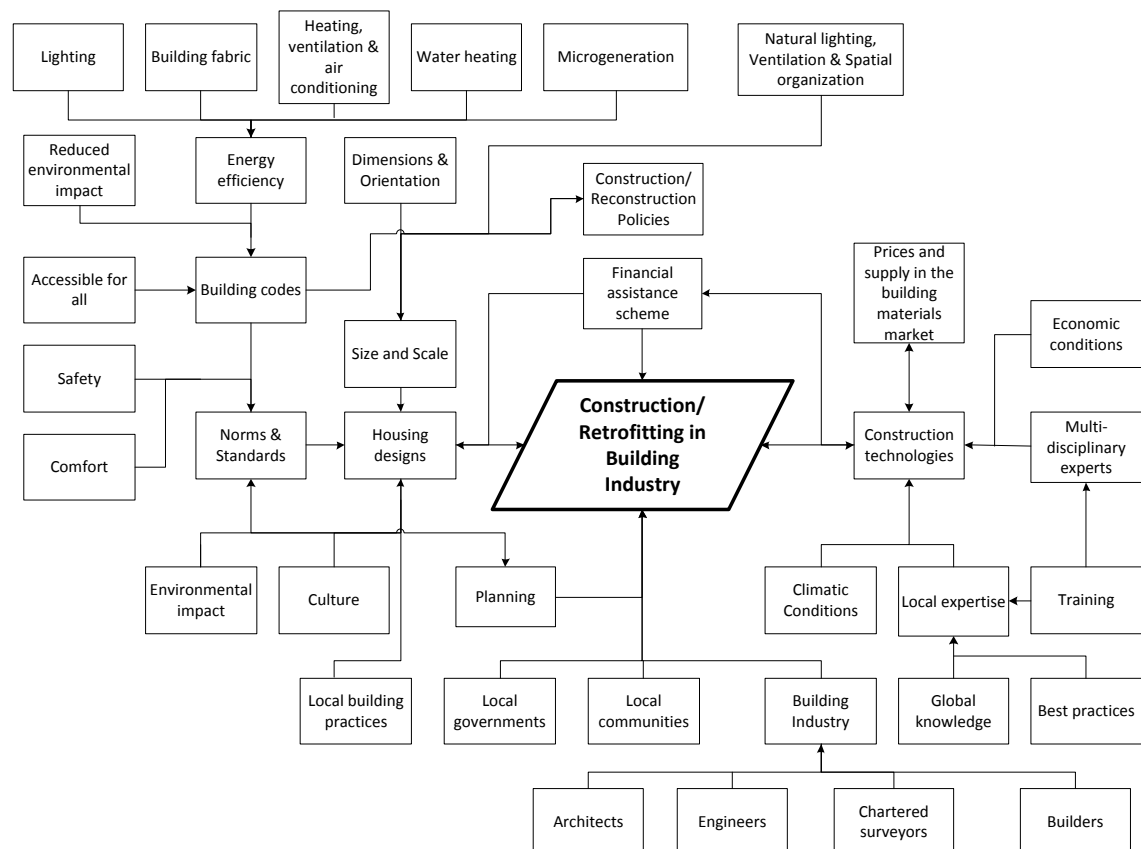


Figure 29: Socio-technical regime for construction/retrofitting in building industry (Adapted from DECC, 2011c; Geels, 2002; Jha *et al.*, 2010).

Niches are protected ‘spaces’ from the existing regime. They are experimental projects to test new and innovative practices. Successful niches change the whole constellation attached to those practices and provide solutions to the existing regime problems. They allow “building of social networks”, “learning and articulation processes” and “articulation of expectations and visions” before diffusing into market (Geels and Raven, 2006; Raven *et al.*, 2010).

8.3.2 Multi-level perspective

Multi-level perspective is widely accepted in transition theory (Rip and Kemp, 1998; Geels, 2002). The transition occurs at three operational levels: macro, meso- and micro- embedded within three analytical concepts: landscape, regimes and niches respectively. Landscapes constitute of macro- level strategies and policies that play a major role in developing regimes and niches (Raven *et al.*, 2010). In the “Green Deal” case, the external and internal social contexts are reduction of carbon emissions; save energy and reduce the cost of imported energy; and reduce the risk of climate change as shown in Figure 3. At meso- level, it would “support” 1000 “Green Deal” apprentices and create 100,000 jobs by 2015; and stimulate economy by adding £10 billion into the economy (by creating feedback). It will also develop a new regime comprising of the competent and skilled actors dealing with the retrofitting industry such as “Green Deal” providers; approved assessors and approved product suppliers. At a micro- level, 14 million buildings would be energy efficient. It would decrease consumption of energy, reduce energy bills and increase comfort (DECC, 2010).

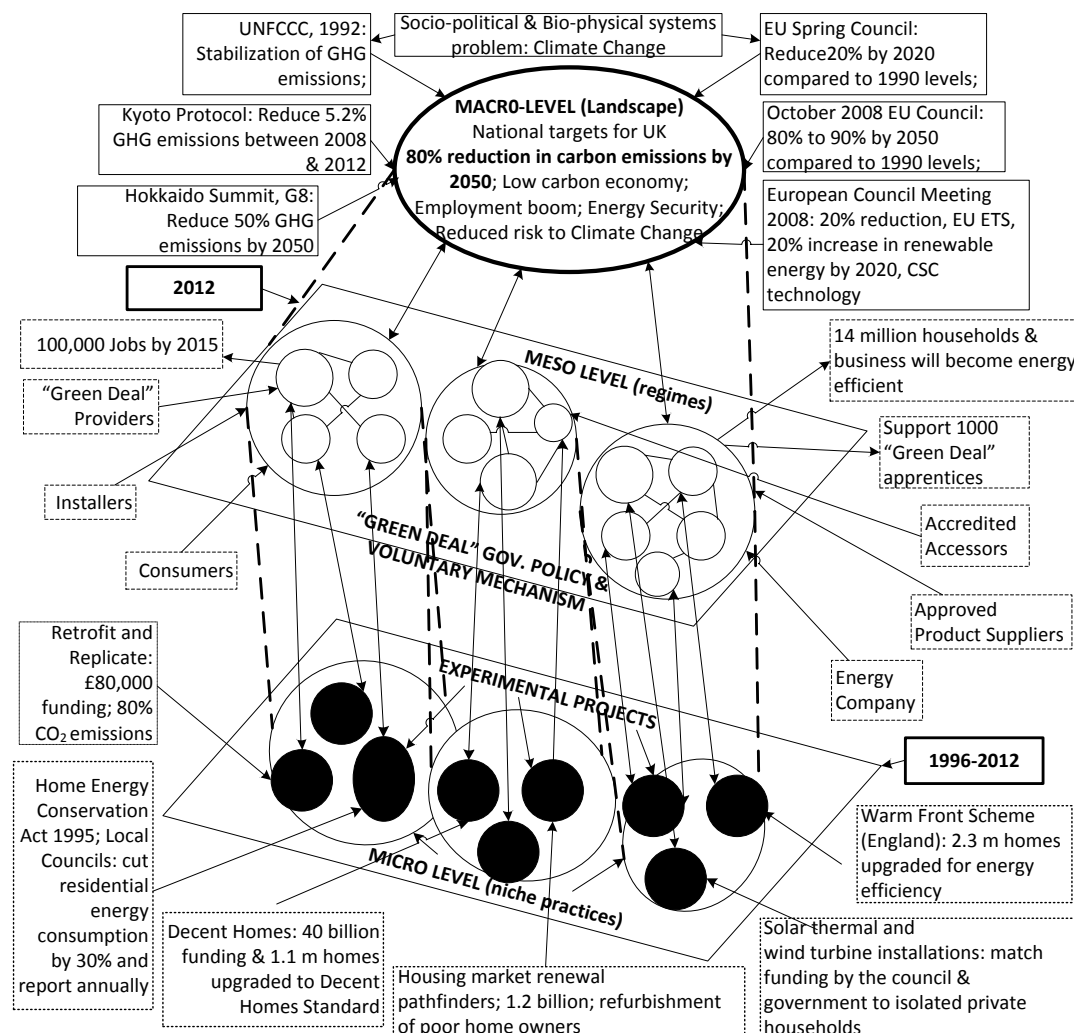


Figure 30: Multi-level perspective of the “Green Deal”.

8.3.3 Innovative financial mechanism

The “Green Deal” is propelled by “a market mechanism, funded by private capital” . It is available to the consumers with no upfront or additional cost. The cost for improving energy efficiency of the building is paid back through savings on energy bills (See Figure 4). The “Green Deal” plans have some prerequisites such as the energy efficient measures should be advised by an accredited adviser and installed by an accredited installer. The “Green Deal” provider should obtain the consent of relevant parties and provide the deal within the terms of the Consumer Credit Act. The golden rule is that the cost of measures should be less than expected financial savings through energy bills (DECC, 2010). The “Green Deal” measures are attached to the building and thus financial obligation also remains with the building. When the building owner moves out, the financial obligation moves to the next bill payer. The “Green Deal” also promotes a ‘whole building’ approach, which means that the improvements have to be carried out only once without having repeated disruptions. It could include hot water efficiency measures within energy efficiency measures. Moreover, micro-generation technologies will be encouraged wherever applicable. Energy performance certificates will be issued to every consumer (DECC, 2011b). A full review of the building based on water, heating and other sources of energy use would be given as part of broader sustainability information under the “Green Deal” .

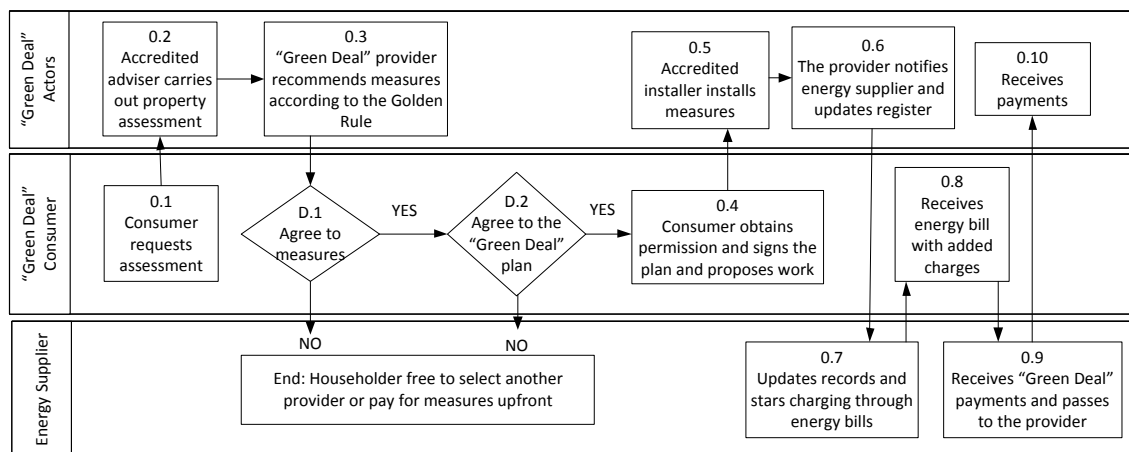


Figure 31: The “Green Deal” plan modus operandi. Source: DECC, 2011.

8.4 THE GREEN DEAL: CHALLENGES AND OPPORTUNITIES

This section critically assesses the role of experimental projects in early stages of niche formation; and whether the innovative reforms attached to the “Green Deal” would harness the niches and lead into incumbent regime, ultimately transforming to a sustainable technological regime.

8.4.1 Experimental projects and niche formation

Since 1996, the UK Government and local authorities have been supporting local experimental projects in retrofitting buildings through various incentives and funding. These experiments have shown successful results such as: reduction of 80% of CO₂ emissions for buildings in Retrofit and Replicate project; solar thermal and wind turbine installations to isolated private buildings in Wear Valley District Council; 2.3 million buildings upgraded for energy efficiency and further 230,000 buildings will receive assistance in 2010-12 through Warm Front Scheme; reduction of 30% of energy consumption through energy efficiency programmes by local councils; 1.1 million buildings brought to Decent Homes Standards (NAO, 2011); and refurbishment of buildings of poor owner-occupiers. Both, technology and actors have matured in acquiring expertise, training and knowledge exchange, theory development through empirical examples, workforce and relevant skills (Hunt, 2008; DECC, 2011c). Carbon emissions from buildings fell by 18%, £800 million were saved on energy bills and £1.3 billion on heating in 2011 (DECC, 2011b). Joh de Souza, director of sustainability, regions, and demonstrations at Constructing Excellence (Hunt, 2008, pp. 5) adds that these experiments have contributed towards the adapting capacity in housing industry, for example, good high density office accommodation; ‘Cooldeck’ night cooling system, or ‘phase change material’ to increase the ‘virtual mass’ to avoid use of energy intensive cooling system for day and night time. Thus, the experimental projects have been successful in stimulating niche formation process.

8.4.2 Supported reforms and incumbent niche

The “Green Deal” is supported by various policy reforms for the niche expansion.

Additional measures such as planning measures: Part L of building regulations; and regulatory measures: Energy Act 2011 would put pressure on private landlords (nearly three quarters of the UK buildings are owned by private landlords (Hunt, 2008)) to have minimum energy efficiency measure. The low-income and vulnerable households would be supported directly by the Government to implement energy efficiency retrofit measures. Further, the UK Government is developing similar policy instruments for low carbon heat to increase the options for consumers. Issuing consumer friendly Energy Performance Certificate would add security and validity for the energy efficiency measures. The broader sustainability review of the natural resources used in the building will be carried out which would serve several objectives such as awareness of energy consumption; development of strategy to decrease energy consumption; and uptake of sustainable lifestyles. Special provisions would encourage local authorities to support social landlords, stimulate the “Green Deal” and provide guarantee to suppliers. Furthermore, the government is working on expensive energy measures and bring the cost down (DECC, 2011b). Thus the uptake of “Green Deal” plans would increase energy efficiency in many properties, improving management practices at institutional level, increase local employment and training opportunities align processes for adaptations and enhancing local awareness on climate change as expected by the Department for Communities and Local Government (2011c).

System-level change is accomplished through the involvement of actors at all levels; and coordination and steering of actions and resources, all contributing towards the transformation processes (Jacobsson and Johnson, 2000). Actors measure the legitimacy of emerging technology differently (Healey, 2008). Further, according to

Berkhout *et al.*, (2003) the niche should be equipped with high profiled and competent actors at all levels falling into institutional, technical and social categories to increase the potential of actualising sustainable transition. This would create new knowledge; influence search directions; increase supply of resources; create positive external economies and formation of markets. In this process the role of governance is very important. Whenever there is a shortage of resources or adaptive capacities, efforts or intervention should be made to deploy and monitor sustainable transition process (Smith *et al.*, 2005). Special publication from the forum for the future (Hunt, 2008) has identified agents for change which include local and regional authorities; housing associations; energy and technology companies; and mortgage providers; estate agents; surveys; communities and individual building owners. These all actors would have to collectively contribute towards achieving targets of 80% reduction of carbon emissions by 2050. SNM literature is not clear about how the values, ideas and interests of various influencers (actors) could be accommodated for the radical shift to sustainable technological regime (Berkhout *et al.*, 2002). The UK government has recognised the need for a competitive market for the “Green Deal” delivery. It has developed training programmes, guidelines and essential support for the development of consumer-facing roles: Adviser, Provider and Installer.

The golden rule of the “Green Deal” expects savings from the energy efficiency measures to be greater than the cost for the measures implement. Paying no upfront cost and savings earned through energy efficiency would undoubtedly be attractive to the consumers. However, not government or the installer can guarantee actual cash savings because the use of the building is subject to the users’ awareness, practices and sense of ownership and responsibility. The implementation of energy efficiency measures at the building site is again subject to owner’ s preferences and affordability. The consumer is the decision maker in *modus operandi* of the “Green Deal” plan as shown in Figure 4. Energy efficiency techniques will involve many technical specifications which would be difficult to understand for a consumer. Also the efficiency techniques would depend on the local social-technical niche. These would constrain a consumer from having easy choice for the “Green Deal” . The niche expansion would depend on the expansion of the local niche. The local niche would have its own characteristics with building types, technologies, efficiency measures and consumers. These characteristics should be measures, quantified and translated into meaningful sustainability indicators for consumers to use in measuring and monitoring sustainability.

8.5 CONCLUSION

The dynamics of the “Green Deal” were analysis using SNM ex-ante approach, it is posited that the “Green Deal” is an innovative mechanism and has the potential of creating sustainable technological regime. Experimental projects, essential for the niche formation process were funded and that allowed innovation for development of essential complementarities of incumbent niche. The skills and knowledge developed by the experimental projects have reinforced the transitions flow. Eighty percent of reduction in energy consumption was received through retrofitting the buildings with the mix of energy efficiency measures; development of institutional and technological capabilities; and building social networks. With the UK government committed to cut 80% of carbon emissions by 2050, there is an urgent need for such projects to scale up widely and go beyond the local level in an integrated way and develop into a

sustainable technological regime, where sub-systems can support each other in a coordinated way for a common goal. The “Green Deal” has been advocated as a pivotal initiative of the UK Government to address the challenges of energy efficiency. This has a natural interface with the global initiatives in response of the global climate change and sustainability agenda.

Analysis of the “Green Deal” show that it is a systematic coordinated response programme, however the role of government is very important in such long term sustainability transition process. As advised by Smith *et al.* (2005), whenever there is a shortage of resources or adaptive capacities, efforts or intervention must be made to deploy and monitor sustainable transition process. Also the role of consumers is very important. The savings through the Golden Rule depends on the actually energy consumed in the building. The Consumer will have to take ultimate responsibility for reducing energy consumption and turn the “Green Deal” into a real financial deal. Though the “Green Deal” has been reinforced by accreditation and consumer protection measures; the government would have to take strategic approach to educate consumer to maximise the benefits. Research findings advocate the need for full engagement with stakeholders. Moreover, it is posited that the delivery and dynamics highlighted in the Figure 4 should also be extended to include a greater granularity of details, particularly in the unit of analysis and metrics employed for measuring and quantifying energy efficiency sustainability indicators.

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9 Energy efficiency for reducing carbon footprint in historic buildings: Comparing case in the UK and Malaysia

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Abstract: Climate changes seem to be one of the controversial conflicts for people in today's world and reducing carbon dioxide emissions, which are one of the main reasons for climate changes, will be an appropriate solution for this alien. Buildings are one of the main resources for producing carbon dioxide emissions. For instance, around 40 percent of all carbon dioxide emission in the UK comes from buildings and so buildings especially heritage buildings need to improve their performance to contribute carbon reduction. The main aim of this research is to identify some acceptable and convenient ways for reducing carbon dioxide emissions in heritage buildings for controlling climate changes to some extent. In this paper, a desktop study was conducted to review the techniques and technologies to help us for reducing carbon dioxide emissions in heritage buildings. In this paper, the importance of heritage buildings and their elements such as wall, roof, window, door, floor has discussed and the main reasons for increasing energy consumption and carbon dioxide emissions have mentioned. In continuing, principles, risks, materials, methods, techniques and technologies for controlling energy loss of historic building elements have expressed. The results indicate that manufactured and transport of building materials will produce a large amount of carbon emissions and so the continued use of historic and heritage buildings can be an accommodative solution for this issue. For instance, in England in 2000 these processes accounted for more than 10 percent of the UK carbon dioxide emissions. It proves that conservation of heritage buildings is important not only for significant value of these buildings, but also for reduction of carbon dioxide emissions. All the methods, techniques and technologies which have discussed in this paper are correspondent solution for the goal of reduction carbon dioxide emissions that produce through the life-cycle of historic buildings.

Keywords: Energy efficiency - carbon footprint - historic buildings - the UK and Malaysia

9.1 INTRODUCTION

In the UK buildings accounted for around 40 percent of all UK carbon dioxide emissions and so the performance of the existing buildings is very important for the goal of carbon dioxide reduction. Based on expectances around 80 percent of existing buildings in the UK will still be in use in 2050. That is why there will be an increase in the amount of producing carbon dioxide emissions in existing buildings.

The UK government believes that “the history environment is an asset of enormous cultural, social, economic and environmental value. It makes a very real contribution to our quality of life and the quality of our places” (Barker, 2011).

The continued use of historic buildings can be an appropriate solution for reducing carbon dioxide emissions based on the fact that more than 10 percent of UK carbon dioxide emissions produce through the process of manufacture and transport of building material in 2000.

We have to understand that most of the historic buildings will not be able to have standard thermal performance as new buildings. On the other hand, historic buildings should be made to perform much more effectively than they do now.

The main aim of this guidance is to propose some correspondent ways for reducing carbon dioxide emissions in historic buildings by using the new techniques and technologies for analyzing building elements such as wall, roof, floor, door, and window to find solutions for controlling energy consumption which has direct relation with carbon dioxide emissions.

The carbon footprint in the span of construction is total amount of carbon dioxide emissions which are produced by activities or are agglomerated over the life-cycle of a building directly or indirectly

The UK government believes that carbon dioxide is one of the main reasons for climate change which is a big challenge for human race and cutting carbon dioxide emissions is a duty for them. The UK government has been trying to reduce the consumption of fossil-fuel for their national goal which has been decreasing carbon dioxide emissions by 20 percent in 2010 and 60 percent in 2050.

Insulation of historic buildings elements is an appropriate solution for reducing energy consumption and carbon dioxide emissions. On the other hand, the significant value of heritage buildings and their elements is a big hitch against experts and limits their ability for controlling energy consumption. Then the best solution for this conflict will be the solution which not only maintain the importance of these buildings, but also improve their performance in terms of energy efficiency and carbon footprint.

The important point that has connected British and Malaysian historic buildings is the same characteristics and architecture of them because historic buildings in Malaysia have been built by British architecture long times ago. Then solutions for improving energy efficiency will be close to each other in both of them.

Historic buildings, in Malaysian context, are defined as buildings that were built in the past 80-100 years or more (S N Kamaruzzaman, Ali, Abdul-samad, & Zawawi, 2009). At present there are over 100 historic buildings are listed under National Heritage and some of them are listed in world heritage list especially building in George Town and Melaka world heritage cities. (UNESCO 2007).

Electricity is the most expensive form of energy which is used in the building especially historic buildings because of their characteristics in Malaysia. Then reduction in electricity will lead to a big energy efficiency and money saving. On the other hand, installing electrical equipment need a small proportion of the total electrical costs in the historic buildings.

Colonial buildings, shop houses, town houses and religious structure such as mosques, churches, temples and clan houses are identified as old buildings in

Malaysia.

The Planning Policy states that: “the public benefit of mitigating the effects of climate change should be weighed against any harm to the significance of the asset (Barker, 2011).

9.2 DESIGNED PROTECTION FOR HISTORICAL BUILDINGS IN MALAYSIA

The agencies such as Department of Heritage, the Department of Museum, the Department of Town and Country Planning and various local authorities in the whole of Peninsular Malaysia have played very important roles for the goal of the protective designation historic buildings which is about the maintaining the heritage entities in the Malaysia. The following are the general mandatory frameworks which have been adopted by the various agencies for implementation.

9.3 The Antiquities Act, Act 168 (1976)

It was down under the control of the Department of Museum and Antiquity in 1976 for preservation of, protection of and research about ancient monument, antiquity, historical object, historical site and monument which are at least one hundred years old. This Department has the obligation to restore and maintain historic sites, but the main defect of their framework is about their limitation to provide a program which can protect and conserve more complex heritage entities such as towns.

There are a lot of heritage buildings which are more than one hundred years old in many parts of the urban areas of Malaysia. Majority of these buildings that have been built before Second World War are playing an important role in identifying the characteristics of these towns. These buildings are going to destroy Because of the process of urban redevelopment and modernization, but unfortunately The Antiquity Act is not able to protect them then, the other established Departments such as the Town and Country Planning and the Local Authority Act can be appropriate for protection of these buildings.

9.3.1 The Town and Country Planning Act, Act 172 (1976)

It is a law governing the urban and rural planning mechanism that provide a system and guidance which is acceptable in Malaysia. Because of the concerns in the urban and rural planning system, several reforms were made through 1993 to 2001 to improve urban heritage conservation. The first amendment which was in 1995 introduces three important sections for compulsory submission of the Development Proposal Report and the 2001 amendment improves the preceding provisions by items such as the establishment of the National Physical Planning Council, the introduction of a new National Physical plan, the need for Structural Plan reviews and the procedure in preparing.

9.3.2 National Heritage Act, Act 645 (2005)

The aim of this Act is “conservation and preservation of National Heritage, natural

heritage, tangible and intangible, cultural heritage, underwater cultural heritage, treasure- trove and for related matters” . This Act is containing of 17 Parts and 126 Articles. The Antiquity Act 1976 and the Treasure Act 1957 have repealed on the same day because Natural Heritage Act considered all provisions of them.

9.4 Literature review

For achieving the goal of carbon dioxide reduction, we need to investigate the building and choose the best interventions based on the significant information which we got during the investigation of historic buildings. For investigating historic buildings we should assemble expert people who can contribute for analyzing the significance, condition, use and construction of heritage buildings.

Analyzing the energy bills which help us to find important information about the amount of energy consumption in historic buildings is a workable way for investigate buildings. The amount of the energy consumption depends on the scale of the buildings, but after the analyzing the bills we will find out how and where energy is used and wasted. Choosing the best interventions such as changing the way the building is used and changing the occupants behavior will conduce to the significant carbon saving.

The Planning Statement (PPS) states the definition of a heritage asset is: “a building, monument, site, place, area or landscape positively identified as having a degree of significance meriting consideration in planning decisions (Barker, 2011).

9.4.1 Investigate the building:

Historic and modern buildings are not comparable in terms of energy performance. In heritage buildings the energy cost are much higher than modern buildings. Because of the attractive features of historic buildings the owner of these buildings closes their eyes to their shortcomings. A consequential stage to a successful carbon dioxide reduction is a good understanding of the building characteristics before any repairing. The occupants use and operate the buildings, the type of construction; buildings' locations are the factors which affect the energy consumption. Analyzing energy bills and comparing with the benchmark that is for similar buildings are the earlier stages for reviewing consumption.

Identifying the energies that are used in the buildings such as electricity and fuel is the next step. Converting the energy figures into a measure of carbon dioxide emissions is a remedy to investigate the energy consumption. Energy in any form such as electricity and fuel has a carbon emission factor. The amount of carbon dioxide that release into the environment will find out from this carbon factor based on the energy usage.

Benchmark is the best standard for assessing and comparing energy consumption in historic buildings and typical buildings whether it is better or worse than them. Bill analyzing is an appropriate method for comparing energy consumption in different kinds of building with benchmark. The process of bill analyzing has several steps:

1. Collecting data about energy consumption monthly or per year for each fuel separately.
2. Plot the energy consumption for each fuel with graphs which show us the amount of energy use in different periods of time. Through the graphs we will find out the lowest and highest amount of consumption during a year.
3. Analyzing annual consumption of different years will show us the building is being operated better or worse than before.
4. Comparing the data with benchmarks
5. Converting the consumption figures to the carbon dioxide emissions figures

9.4.2 Complementary techniques:

There are some useful techniques which show us the area of energy loss or consumption:

9.4.2.1 Thermal imaging

External elements of the buildings such as roof, wall, floor, window and door act as a thermal bridges in buildings. Through these thermal bridges the cold external and warm internal environment transfer. Infrared imaging camera highlights the area with the risk of thermal bridging by using different colors. This camera by using the colors blue, green and yellow to red show us the ranges of thermal efficiency from the coldest to warmest areas. By using this method, we will find the weakest points in the in buildings in terms of energy consumption, areas with poorly performing insulation, and zones with high thermal bridging. Thermal bridging can be caused by water which infiltrate into the building fabric because of raining or rising damp.

9.4.2.2 Air pressurization testing

By using this method, it will be founded how much air escapes from the building. Air infiltration has the highest proportion of energy loss in historic buildings and through this technique we will find the amount of this infiltration. Using smoke generation in this method provides a situation for us to find out where the building has air leakage point.

9.4.2.3 Thermal modeling

We can have an initial estimation of energy losses through building fabrics with using a thermal model. Thermal modeling is a process of modeling and assessing the result of energy consumption by using modeling specialists.

9.4.2.4 In situ U-value testing

We can gain an accurate estimate of thermal performance of building structure such as wall by using this technique.

9.4.2.5 Environmental data logging

This technique measures the amount of humidity in interior spaces by monitoring the temperature and humidity. Then the data is plotted to show environmental conditions and seasonal fluctuations in detail.

The character and physical behavior of historic buildings should be understood before

any trying for enhancing their performance to the level of modern standards. The key process for successful improving energy efficiency in historic buildings is to complete these stages: 1-reduce demand 2-maximise efficiencies 3- renewable technologies.

Behavior change will be an acceptable solution for reducing demand. For increasing energy efficiency, we need to standardize building fabrics and systems.

9.4.3 Behavior change:

Behavior change can lead to low energy consumption at any scale of the buildings. Some additional attentions for changing the behavior such as filling washing machine before using, using energy saving lights bulbs, using timer for bulbs in the areas like stairs and turning off lights when leaving a room can reduce energy consumption by up to 20 percent.

9.4.4 Historic building fabrics:

Significant value of historic buildings depends on their fabrics, elements and systems. That is why external changes for these buildings seem to be unacceptable because this process impact on the character of the buildings. Then internal changes such as insulation with using accommodating materials and careful detailing will be more appropriate for heritage buildings. We can separate elements in historic buildings in terms of their significant value into three groups high, medium and low. Reduction of carbon dioxide emissions in alteration the building fabrics and elements is much more than installing renewable energy in compare. Then replacing the low significant value of historic building elements with more efficient equipollents are more likely acceptable. In addition, improving air tightness will be another workable solution for increasing energy efficiency in historic buildings based on the large amount of infiltration rate of external air into the internal environment. Improving the air tightness in historic buildings can lead to enhancing energy efficiency up to 40 percent.

9.4.4.1 Roof

Roofs in historic buildings which can lead to around 20 percent of heat loss perform an important role in defining these buildings character and insulation can be an appropriate solution for reducing energy lost. There are a choice of widely insulation materials such as mineral and glass wool which are located between and over the roofs joists in a cold roof. The minimum depth for these materials is 270 mm. Careful detailing can be a hitch for thermal bridges which occur at gaps in the insulation and junctions with chimneys and external walls. Holes around pipe and duct should be closed up for controlling air infiltration into the roof space. The importance of the problem that extra insulation of roof will lead to an increase in dampness and condensation needs lots of our attention. For those historic buildings that do not have a ceiling below roof level, rafter can be an appropriate place for insulation. Natural and breathable materials such as wood fiber are suitable for natural ventilation.

9.4.4.2 Wall

The majority of historic buildings have solid masonry walls which have poor thermal resistance and are responsible for 30-40 percent heat loss. Because of the significant value of historic buildings external insulation systems are not acceptable. Internal insulation can lead to major improvements in carbon dioxide emissions reduction.

Modern material such as Polyurethane and Aerogel are not suitable for historic buildings and will cause some problems such as loss of breathability and financial problems. Then in these cases natural and breathable materials for insulation such as wood fiber board will be more acceptable too. External insulation except damaging the character of the buildings can cause other technical issues such as:

- **Vapor build-up:** condensation through the permeable wall from the internal vapor will be possible.
- **Detailing:** increasing the expense of the overall work because of designing details for hiding the wall thickness which is caused by the external insulation.
- Internal insulation also has some technical matters like:
- **Detailing:** internal insulation needs careful detailing for windows and doors
- **Cold bridging:** breaks in insulation layers can lead to cold bridging
- **Loos thermal mass:** internal insulation will lead to losing thermal mass which is responsible to moderate the temperature of the room inside

9.4.4.3 Floor

The insulation of the floors depends on the kinds of the floors. In solid floor, material is very important for treatment and if the replacement is possible, we can use breathable materials such as lime Crete. For suspended timber floors, the insulation material can locate between the joists.

9.4.4.4 Window

Windows have an important proportion in the significant value of the heritage buildings because they are highly visible internally and externally. Then any trying for improving the energy efficiency and controlling the energy loss through these windows need careful detailing. Historic significant window frames such as leaded lights and crown glass need to be maintained and inappropriate modern windows should be replaced.

Replacing the single glazed windows with high performance double glazed windows is a workable solution for reducing energy loss. Another solution for this energy loss can be secondary glazing which fills the entire window opening for controlling the cold bridging issues through the steel window frames. Internal and external shutters can also reduce energy loss from heritage buildings at nights and when they are empty. In addition to these techniques, it should be remembered that the use of heavy curtains or well-fitting shutters can approximately have the heat loss through some types of windows (Barker, 2011).

Draught proofing which is the most-effective method for insulating windows can reduce air infiltration through some windows as much as 86 percent in good condition.

9.4.4.5 Door

Timber is the main material for most of the external doors on historic buildings. Most of the time heat loss through the historic doors is because of the infiltration around the perimeter of the door. Repairs and draught-proofing can be the appropriate solutions for reducing energy loss through these doors.

9.4.5 Low and zero carbon technologies:

Installing new technology in historic buildings for improving energy efficiency is challenging because they were not design to operate like modern buildings. Low and zero carbon (LZC) technologies not only need to be suitable for historic buildings technically but also should be installed after improving building elements performance. Low and zero carbon (LZC) technologies are considered on the following pages:

Biomass boilers: this technology uses wood which burn directly or is used for producing gas to generate heat. Using an external boiler-house minimize the impact of this technology on the character of historic buildings. The most important advantages of this technology are using fuel with a low carbon emission factor.

Solar thermal: through this technology that is available in two forms, flat-plate (FP) and evacuated tube (ET), we can generate hot water from solar energy. Using panels at roof levels will provide a situation that will not damage the significant value of heritage buildings. This technology has better result than flat plate collectors.

Photovoltaic arrays: it converts solar energy into electrical energy and have two main types: Crystalline and Mono-Crystalline. We can locate this technology like solar thermal and hide it from any significant view-point.

Small wind: it requires a minimum wide speed of 6 km/s. the problems such as vibration and noise appear through using this technology need to be considered. This technology can store electrical energy when there is not any wind.

9.4.6 Malaysian historic buildings

Most of the historic buildings in Malaysia are still in their original state but being fitted with electricity, water as well as air conditioning. Some of the buildings were also upgraded or renovated to more advanced services system, which end up using high consumption of electricity (S N Kamaruzzaman et al., 2009).

The most important form of energy which is used in historic buildings is electricity. Energy consumption of electrical equipment depends on the design and characteristics of historic buildings such as their ventilation, lighting, heating and cooling system and occupant behavior. Based on the climate condition in Malaysia, no heating system has been used in historic buildings. The three main end-uses for electricity are air-conditioning, lighting and electrical equipment.

9.4.6.1 Air-conditioning

Domestic-scale package system and a split system are two common types of air condition system in Malaysia. The first one which serves just one room placed on window units and walls. The second one placed outside while evaporator and fan located inside the buildings.

9.4.6.2 Lighting

The amount of energy uses through lighting depends on the power of the lighting equipment and the duration of their application.

9.4.6.3 Electrical equipment

The quantity, power rating and hours of operation of the electrical equipment such as computers, monitors, printers and copiers can show us the amount of energy uses through this equipment.

With comparison these results to an existing energy benchmark (CIBSE, 1991, 1998, 2004), air-conditioning and electrical equipment operate according the benchmark. On the other hand, lighting consume energy more than what is expected through benchmark.

9.5 CONCLUSION

It will be possible for us to improve energy efficiency and reduce carbon footprint in historic buildings. In this paper, we explain the definition of carbon footprint and the main results which lead to increase the amount of carbon dioxide emissions in the environment through the life-cycle of the heritage buildings. In continued, we illustrate building elements such as wall, roof, floor, door and window and their significant value in heritage buildings. Based on the importance of the building elements, there are some acceptable technologies for reducing carbon dioxide emission in heritage buildings. All the information above proves that reducing carbon dioxide emissions in historic buildings need accommodative technology that not only maintain the significant value of these buildings but also control the risks and improve energy efficiency. For Malaysian historic building case, the most effective solution for improving energy efficiency can be improving occupants' awareness about energy consumption and the ways for using and maintaining energy which lead to carbon dioxide reduction and it will be possible through energy awareness program. Above all, this paper mentioned to the main reason for energy wastage in historic buildings in Malaysia which is through lighting and researchers are going to find a solution for this gap. We will mention to the correspondent solution for this issue in our next papers.

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10 Alignment problems of timber production in Architecture-Engineering-Construction Projects

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Abstract: Due to the negative effects of the carbon-dioxide on the ecosystem, the Architecture-Engineering-Construction industries are looking for the new materials with lower carbon-footprint. One of the best natural materials that can be used in AEC industries is wood and its derivatives. However, due to the physical and chemical properties of timber, the application of it in AEC industries, especially in the process of manufacturing and production, encounter with some difficulties and obstacles; and they are causes of decreasing the speed and increasing the cost of production in AEC industry. The most important problem in the process of off-site manufacturing of the wooden pieces is caused by the differences between dimensions of pieces in drawings with the dimensions of it that need to be set for the workshop machinery. These changes are not only necessary in the process of sawing pieces, but also in the other processes such as assembling and making the details. Therefore, during the process of manufacturing and production of the wooden pieces, there are a lot of changes on the dimensions of a component in the production drawings and they negatively affect the manufacturing process and, hence increasing the cost and delaying in production. The aim of this research was to find and identify the reasons of these changes in order to mitigate the risks. The research adapted a desktop study followed by direct observations in order to identify the major problems and obstacles. The results showed the problems are mostly due to the tacit nature of design knowledge and lack of proper knowledge of the designers about the actual process of timber production. This research is a novice attempt for expediting timber production process in order to leverage sustainable and modern methods of offsite manufacturing oriented construction.

Keywords: IBS, Timber, Drawing, Manufacturing process, Architectural design, Off-site Manufacturing

10.1 INTRODUCTION:

This research was motivated with the first author's background professional experience regarding the obstacles and barriers in production and manufacturing of wooden furniture and constructional components. The author has been acting as the owner and director of an interior design and wooden component manufacturing company for nearly 20 years. The most important of those problems was the necessity of changes in the architectural drawings of the wooden pieces at the early stage of manufacturing; and it was not only the cause of a lot of serious arguments between manufacturing skilled workers and designers, but also slowing down and sometimes stopping the process of production and finally leading to the noticeable losses. Nevertheless, using any possible methods such as replacement of the workforce with the new one there was no any success on the matter. The eager to doing the research on the said topic became much more when the author became an investigator and inspector of the government in AEC sector and it provided an opportunity to get access to the information about the other wooden manufacturing companies in Iran; and surprisingly all of them were encountered with the problems of not matching architectural drawings with the technical drawings. Some of manufacturers even made a lot of changes on the process of production through spending noticeable investment on the purchasing new wood production machinery in order to mitigate the

aforementioned problems. Surprisingly, most of the wooden component and furniture manufacturers had been included to allocate the fixed budget (5-15% of their turnover) on the matter (the losses that come from the differences of the architectural drawings with the workshop drawings) as a part of annual expenditures of the company. In some cases, this issue caused bankruptcy of the company in long term.

The importance of this matter was as much that it became an issue for all managers and owners in wood industry sector and they were trying to mitigate the problem by any possible methods. In some cases, this matter and disadvantages of it on the loss-and-gain put the companies on the critical situation; and in order to survive they decided to remove the design and architecture department from the company. Some of them, as a solution, even attempted to replace the designers with the skilled manufacturing workers; however there was no improvement in this case also. When during some conferences, exhibitions and annual professional wooden and timber industries meetings in the other countries in which the first author represented Iranian government (e.g. in Germany, Turkey, Russia, France, UAE, Malaysia, Iraq, Pakistan, Armenia, Kuwait,) the intellectual discussions proved that this problem exists in the other countries also. As such, the main motivation of the study was first to investigate and identify the types of such alignment problems in timber industry and then try to find solutions for mitigating the problems.

10.2 LITERATURE REVIEW

Due to the alignment problems of timber production in AEC industry, there is a high level of waste in the use of wood and timber as one the most important natural resources. According to “The United Nation’ s Food and Agriculture Organization (FAO), total global round wood production has increased from 2,463 million m³ 1970 to 3,358 million m³ in 1994 (roughly a 1.3% increase per year). While some predict that sufficient wood fibers will be available in the future globally others project significant gaps in supply chain. Apsey and Reed quantify this gap as some 400 million m³ in 2010 and nearly 600 million m³ in 2020 and Nilsson puts the numbers at 800 million m³ and 900 million m³ for the same dates, respectively. From 1970 to 1994, the worldwide consumption of wooden panels increased by about 2.9% annually, to a total volume of 126.4 million m³ in 1994. According to FAO, the rate of growth is expected to stay above 2.0% annually for the next decade, resulting in an estimated consumption of 172.6 million m³ in 2010. For this reason, wooden furniture and component manufacturers and face increased need for their raw material and upward pressure on raw material prices” (Buehlmann, Ragsdale, & Gfeller, 2000). On the other hand, there has been proven a significantly low constructional cost for a timber building (6-15%) compared to similar houses constructed by prefabricated concrete or steel. (Stehn & Bergstro, 2002), availability and ease to work, flexibility, good performance under influence of wind and earthquake, natural beauty, inexhaustible supply and its structural properties.

In overall, timber compared with stone and concrete can be used for either tension or compression stresses(Hunt, 2012) and it has become the causes of increasing the usage of it in many construction sectors such as railroad and bridge and many other application (Kozem Šilih & Premrov, 2010).Nevertheless, an increase on the demand of timber and shortage of its resources as a raw material in worldwide the studies show that during the process of the manufacturing wooden components 7% up to 40-50% of

the annual supply of timber raw material is wasted as a residues and it is caused of 2-8% of turnover as loss (Daian & Ozarska, 2009). In addition every year the noticeable money are spent on the maintenance of timber buildings and much of them because of the mistakes of designers or builders for example in the UAS, Californians are spent nearly 364 million USD annually on this matter (Morrell, 2002). In according with the above reasons in order to survive the domestic and overseas wooden component manufacturers, managers, experts and companies must remove the barriers and difficulties of the wooden off-site manufacturing and it is essential to reassess their working behaviors and to redesign and to reequip themselves to take a part and to compete in a dynamic environment. To achieve this goal it is required to operate the integrated manufacturing system and to use the aspects of product design, production engineering and quality control and to remove the barrier of the production in wooden industry sector (Pegler & Kochhar, 1988). The aim of this research was to find and identify the obstacles and barriers of wooden off-site manufacturing in order to decreasing the number of mistakes and the delay on process of production that altogether are caused of increasing the production cost and decreasing the speed of wooden component production.

10.3 RESEARCH METHODOLOGY

To achieve to this goal, the study investigated the barriers and difficulties of 30 Iranian wooden component/ wooden furniture companies based on direct observation, constructed interview and a survey of the practices and performance of them in prior of the 1990-2011. To more understanding and finding the problems and their reasons the study took the views of the personnel in all timber production process. This research also investigated the losses- gain account' s records of companies in relating to timber production' s problems.

10.4 RESULTS AND DISCUSSION

During the product process of timber components there are many phases that are included planning, concept, system-level-design, detailed design, testing and production ramp-up (Rodríguez, de Ciurana, & Elías, 2005). The product development process needs a corrected and different levels of involvement by important functions of the individual sections such as design section, analysis section, first necessary material preparation section, cutting section, assembling section, quality control section and finally delivery section. In general, after finishing the design process the architectural drawings are passed to the production section for manufacturing. In this stage, the skilled workers and experts start to calculate and to analyze the drawings to identify the production essential materials such as wood and joints. They also identify the essential production time. Then, ordering the necessary manufacturing material to the material preparation department. After preparation the materials, the cutting section' s personnel start to cut the wooden material and then, pass the cutted pieces to the assembling to manufacture the product and finally after quality controlling the product will deliver to costumer. In one hand with the consideration of the process of production of timber and wood from the natural resource (forest) and on the other hand, its physical and chemical properties and the necessary of the industrial machinery in manufacturing an production of the wooden constructional elements. The most ideal method is off-site manufacturing and the same as the other industrial products and materials the production and application of it in AEC industries needs to proceed the stages presented in Figure 1.

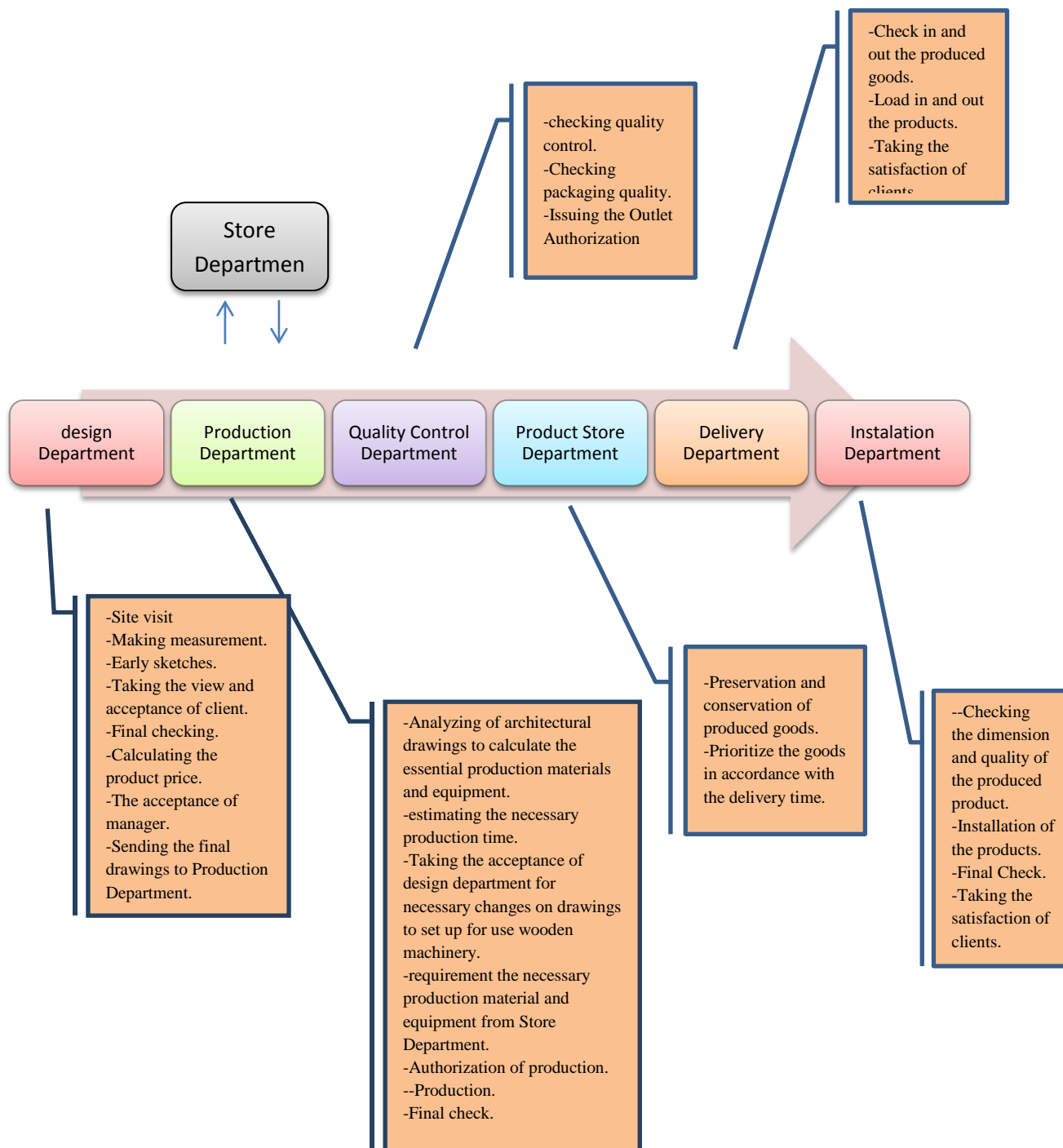


Fig 1. The diagram of wooden pieces manufacturing process

However, according to the direct observations from the case studies(30 wooden component manufacturing companies), the study found that the application of it in AEC industries especially in the process of manufacturing and production is encountered with some difficulties and obstacles and it has become an issue for the constructional

experts and managers to find a solution for it. The main barriers and problems that are caused a lot of difficulties in wooden manufacturing process are as following:

10.4.1 The necessity of making changes on the dimension of architectural drawings to set for wooden machinery

One of the most important problems in the process of off-site manufacturing of the wooden pieces is “The differences between Architectural and Engineering drawings with the workshop drawings” . In accordance with the instruction of the wooden industrial machinery, there are many differences between the dimensions of architectural and engineering drawings of a wooden piece to set for using by the wooden machinery in a workshop or factory. It means that to produce a wooden piece in the factory the dimensions of the Architectural drawings need to change. Figure 2, illustrates an example of the differences between the dimension of a wooden piece in Architectural Drawing and the actual dimensions needed for workshop drawings in manufacturing process.

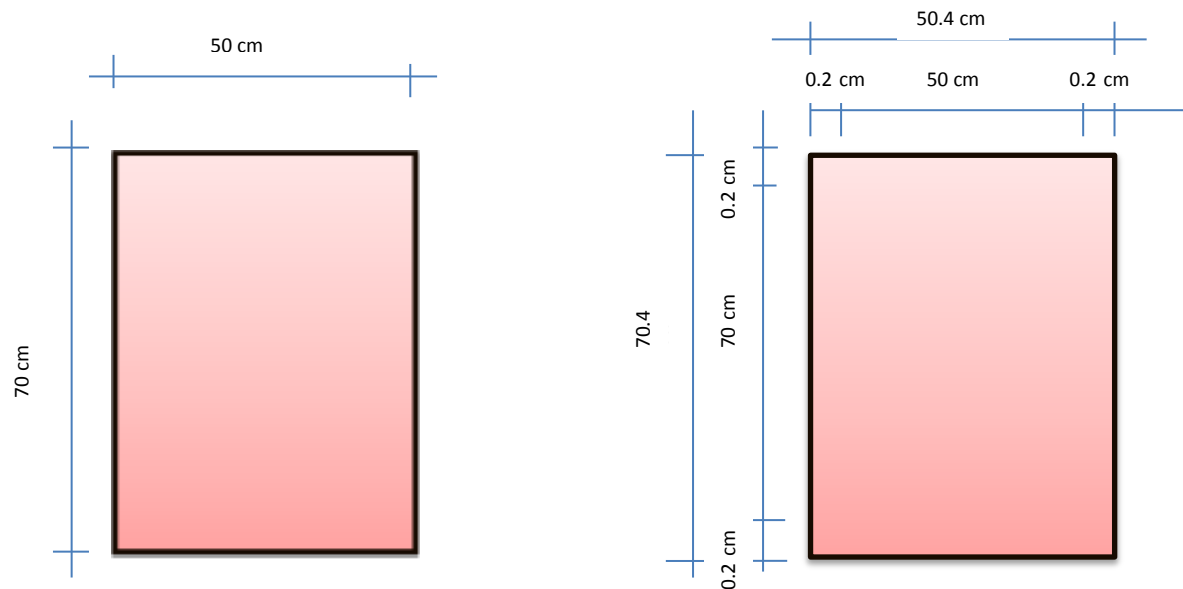


Figure 2. The differences between the dimension of a wooden piece in Architectural Drawing and workshop drawings in manufacturing process

The reasons of the above changes refers to making the piece with the shape of rectangle, the piece needs to be sawed 1 time from each side and due to the rectangle has 4 sides so for making the shape of rectangle the piece altogether needs to be sawed 4 times from sides. On the other hand, in sawing every side of the wooden piece, the sawing machinery decrease 2 mm because of the thickness of its saw. Thus to achieve the 50 cm breadth the mentioned corrected breadth of the piece in drawings should be $50 + 2 (2\text{mm}) = 50.4\text{ cm}$ and with the corresponding calculation for the length of 70 cm, the mention corrected length in drawings for setting for wooden machinery is $70 + 2(2\text{mm}) = 70.4\text{ cm}$. The above necessary changes to the dimensions of wooden piece are just for sawing process. Whereas, there are another essential

changes on the dimensions of the wooden piece to set any wooden machinery such as edge banding machine and milling machine. For example, if designers want to add the PVC Edge band to the edge of the piece designers should add the essential calculations of the edge banding machine based on its instruction of the PVC edge banding machine to the dimensions of the piece in Architectural drawings. Furthermore, a wooden product is contained some or many pieces and changes which mentioned above should be done for all of them separately. The above changes are necessary not only in the sawing process of pieces but also in the other process such as assembling and making the details. Thus, in the manufacturing process of the wooden pieces, there are a lot of changes in architectural drawings and these changes will cause to some negative effects as following on the production process and finally lead to increasing the cost and decreasing the speed of production in AEC industries:

10.4.1.1 The delays in production process

Basically, careful calculation needs time spending and in the duration of the manufacturing process it is counted as a negative factor and leads to the delay on manufacturing process.

10.4.1.2 Increase in mistakes made by the designers

Due to the high variety and high proportion of the analyses and calculations for necessary changes of the architectural drawings for setting for the wooden machinery, the possibility of making mistakes is increased and it has a lot of disadvantages on this process.

10.4.1.3 Reduction of the architectural quality, foundations and principles

Due to the Lack of information of the personnel in the manufacturing and production sectors from the foundations of the architectural design, sometimes the changes of the architectural drawings lead to removing the foundations of the architectural design such as forms, rhythm, concinnity, symmetry, composition, harmony and continuity from the products.

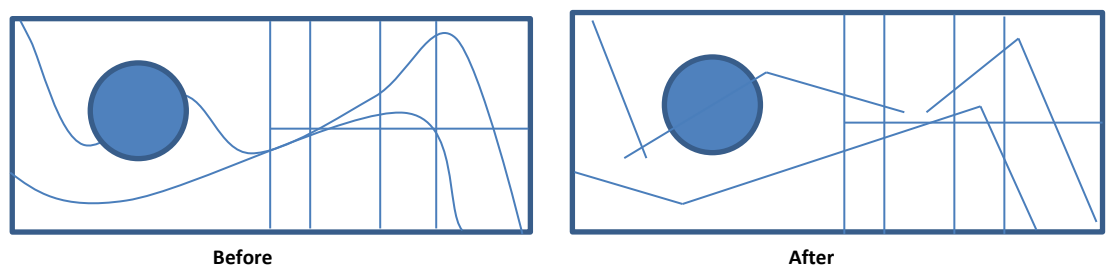


Figure 3: Removing the architectural foundation of design is resulting from the changes on the drawings in the factory

10.4.2 The changes of locations, specifications of details

Due to the dimension' s limitations of the wooden pieces, sometimes it is necessary to make the changes on the factors such as locations, thickness, and connection between pieces. For example, maximum available dimensions of a wooden panel that is used in wooden industry in accordance with the particle board' s dimension is (3.66 cm × 221

cm), whilst sometimes the mentioned dimensions in architectural drawings is more than 366 cm 221 cm (425 cm × 246 cm) and it as an unexpected work which leads to changing the details, extra work and stopping the production process to make the changes and take the permission of the design sector.

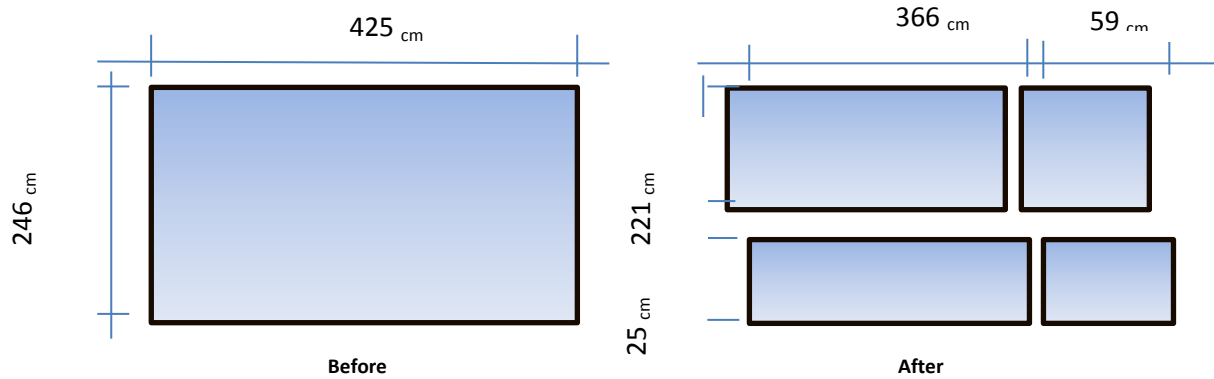


Figure 9. The diminution limitation of the wood can be caused of changed in the form, color, joints and thickness of the wooden

10.4.3 The changes of the structural specifications of pieces

In general, in the production process of wooden components especially in wooden furniture production process there is no viewpoint of structural engineering analysis and the design is done based on the general knowledge of the designer about structures and sometimes, it leads to changes in the architectural and engineering drawings. For instance, due to the change which is existing in form and the stiffness of a wooden element by the thickness of 16 mm and length more than 150 cm, there is not any possibility of usage of it in this condition specially in the vertical position or as the foundation of the other pieces (Criswell, 1990).

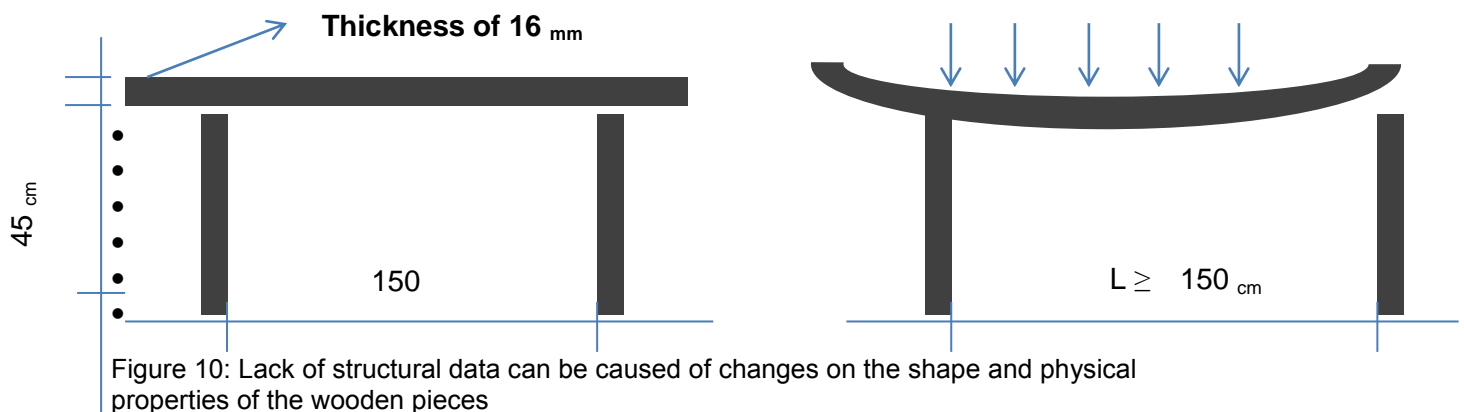
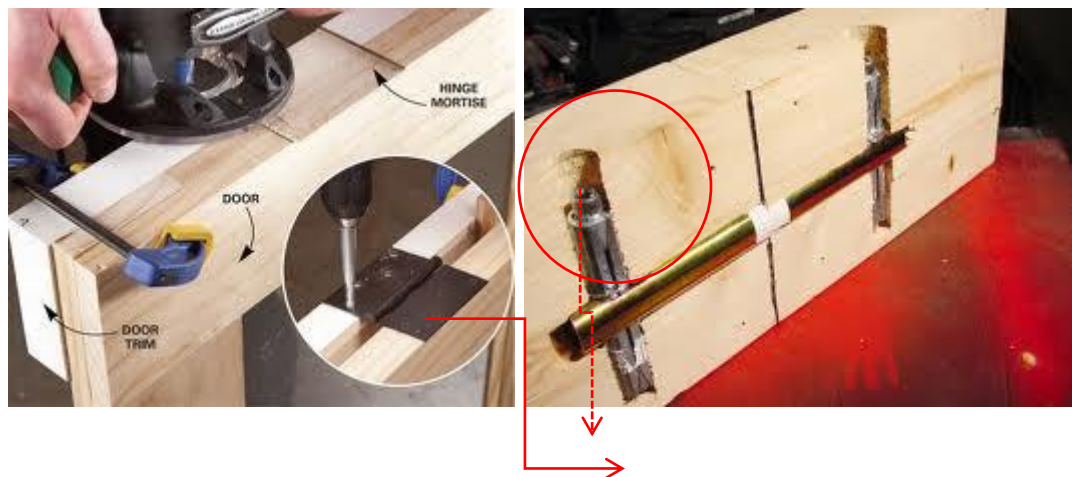


Figure 10: Lack of structural data can be caused of changes on the shape and physical properties of the wooden pieces

10.4.4 The changes of the locations and specifications of the joints

Joints can be counted as the weakest part of timber structure and the loss of properly performance of them lead to global stiffness of the timber structure and an increase of the assembled elements’ dimension (Chen, Lee, & Jeng, 2003). The qualitative and quantitative properties of the wood have the directive effects on the design of the details and joints and sometimes the way of joints of the wooden pieces leads to some changes on the architectural and engineering drawings. For example, installation of a hinge on the wooden pieces with the thickness of below 8 mm is impossible. While, sometimes the mentioned thickness in architectural drawings is below than 8 mm.



wooden piece must be ≥ 8 mm The least thickness of the

Figure 11.The wooden details need to the essential dimension and physical property of the wooden pieces

10.4.5 The changes of the specifications and the properties of the wooden pieces

Because of the differences of the mentioned specification in the architectural drawings, with the available real specifications making the change on the specifications of the product is essential. For example, some colors that designer mentioned in the drawings does not produce and available at all.

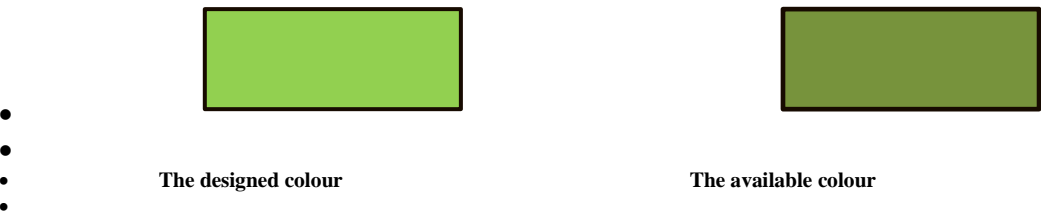


Figure 12: The shortage of available colour is cause of change in architectural drawings

10.4.6 The changes in the final dimension of product and dividing it to the smaller pieces

Because of delivery limitations it is essential to divide the heavy and big pieces to the light and smaller ones to prevent the wooden pieces against the damage in delivery process.

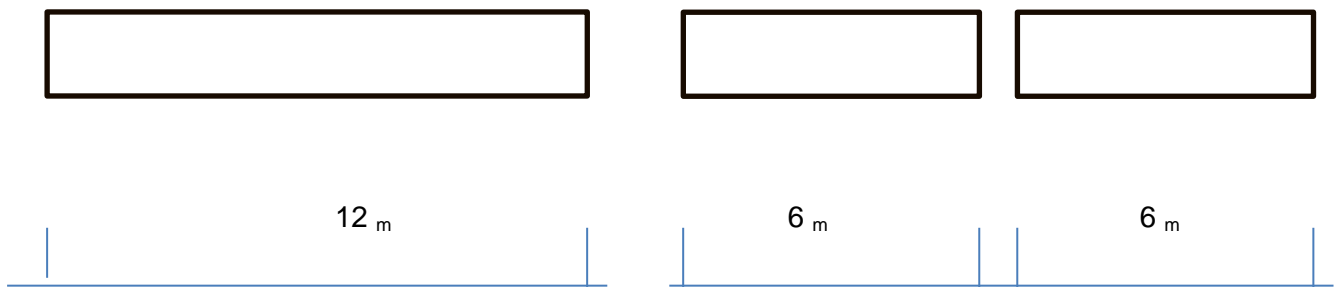


Figure 13: Dividing the long length to short length to make it deliverable

10.4.7 The changes in the forms and design of the wooden pieces

Because of impossibilities or difficulties of making some forms such as arc by wooden materials the change on the forms and shape of components is necessary.



Figure 14. The necessary change of form of the wooden component before and after production process

10.4.8 The changes in the final dimensions or the specifications of product

Because of the limitation on the installation place, sometimes it is necessary to make a change on the specifications of the product based on the condition of installation place. For example, in humidity areas the manufacturer must add the water Proof Stuffs to the wooden components or change the hill' s height and it may leads to a change in the color or the used material.

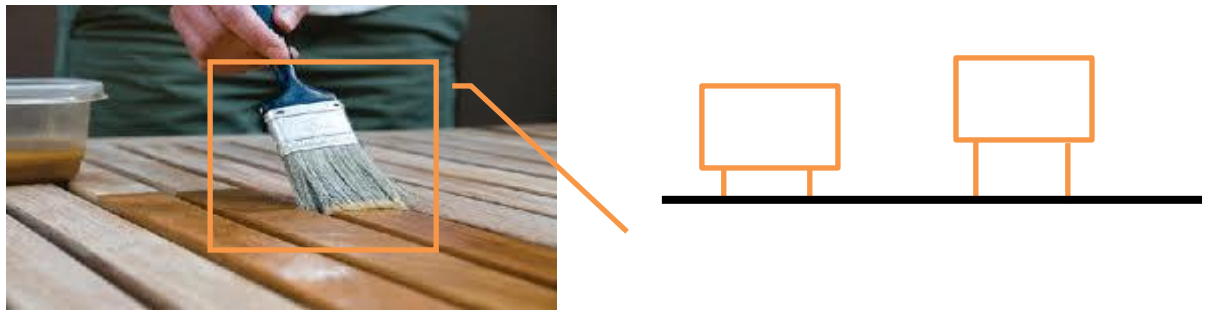


Figure 15: The Changes of the colors and height of wooden pieces before and after production process

To find and focus more and deep on the topic, the study have taken the views of the managers, designers, production engineers, quality control engineers, skilled workers, deliverers and installers. The findings showed that all of the personnel in production department are dealing with the changes on the architectural drawings and it has become a critical problem for the all 30 companies. The study also have found that in some companies in which the designers have been working for more than 5 years over there continuously, the number of the changes in the process of the manufacturing is much lower than the others. In addition, in a few of the companies that were using the full Automatic Wooden Machinery (CNC) in comparison with the others (Manual/ CN wooden machinery)due to the necessity of using the computer knowledge to making the changes on the architectural drawings the problem was much complicated. Furthermore, in five of the companies that were using the skilled workers instead of the designers in comparison of the others the number of the changes on the architectural drawings has been two third of the others. Interestingly, in these five companies the skilled workers were designing two times for a product. One of them is for the general design and the other one for production process. Two of the companies' managers had decided to send some of their skilled workers to architectural trainings as a solution of the problem.

10.5 CONCLUSION

Whilst there is an increasing tendency to apply timber as an acceptable replaced material with the lower carbon foot print in AEC projects, it is important to increase the application of it through removing the difficulties and barrier of timber production process. The study discussed that the most main problem in timber off-site manufacturing process is the differences between the architectural drawings with the

workshop drawings. This research also ascertained that this difficulty comes from Lack of information of designers involve wooden Industry that leads to increasing the production cost and decreasing the production speed. Therefore, this study conclude that to remove the timber production's problems, it is essential to arrange the training subjects for designers about the way of manufacturing timber components in off-site manufacturing in AEC projects. The designers involve in wooden AEC industries and projects also need to know the necessary specifications of wooden components to be set up for wooden machinery. On the other hand this will likely enhance the ability of wooden components producers and firms to exist and compete in local and foreign markets by lifting the level of performance on a variety of objectives.

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11 Assessment of Carbon Dioxide Emission from Road Transportation in South Eastern Part of Niger State, Nigeria

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Abstract: Climate change, often referred to as global warming, is considered to be one of the greatest environmental threats facing the world today is caused by the emission of greenhouse gases (GHGs) into the atmosphere. The principal greenhouse gas is carbon dioxide. One prominent source of carbon dioxide emission is the transportation sector. Not much was known about the emission levels of carbon dioxide, the primary greenhouse gas from the road transportation in the study area. Therefore, this study assessed the levels of carbon dioxide as a greenhouse gas emission from road transportation in the south eastern part of Niger State. The three major south eastern cities investigated are; Minna, Bida and Suleja. The database shows the carbon dioxide data collected and their sampled junctions Gasman carbon dioxide gas meter was used to take the carbon dioxide emission readings in Parts per Million for the peak and off-peak periods of vehicular movement at the selected sample road junctions with their Global Positioning System GPS coordinates in the Universal Transverse Mercator (UTM). Further statistical analysis was also carried out on the data recorded from the field using the Statistical Package for Social Sciences SPSS software to show the variance of the emission levels across each of the locations of interest in the study area. The results established that emissions' level of carbon dioxide from the road transportation in the study area exceeded the internationally accepted safe limits of 350 parts per million needed in the atmosphere. In the light of the conclusions, recommendations made for climate change mitigation via carbon dioxide emissions reduction from transportation includes; introduction of the urban mass transit and the use of vehicles using renewable sources of energy.

Keywords: Carbon Dioxide Emission Assessment, Road Transportation, Niger State, Nigeria.

11.1 INTRODUCTION

11.1.1 Background Study

Global warming or climate change is simply defined as measurable increases in the average temperature of Earth's atmosphere, oceans, and landmasses. Climate change, often referred to as global warming, is considered to be one of the greatest environmental threats facing the world today. Scientists believe Earth is currently facing a period of rapid warming brought on by rising levels of heat-trapping gases, known as greenhouse gases, in the atmosphere. Centre for International Climate and Environmental Research (CICERO) (2008) stated that the global emissions from different transport sectors (road, rail, shipping, and aviation) in year 2000 affect the future temperature. While air transport has some strong climate effects that decrease relatively quickly over time, emissions from road transport have a strong and long-lasting effect on climate.

There is now scientific evidence that, carbon dioxide (CO₂) concentrations in the atmosphere increased from approximately 280 parts per million (PPM) in pre-industrial times to 382 PPM in 2006, a 36 percent increase. According to the National Oceanic and Atmospheric Administration's (NOAA) Earth Systems Research Laboratory, almost all of the increase is due to human activities (IPCC, 2007). With more emission of

carbon dioxide, the atmosphere acts like a thickening blanket and traps more heat. (Encarta, 2009).

Figure 1.1 shows the history of atmospheric carbon dioxide concentrations as directly measured at Mauna Loa, Hawaii. This curve is known as the Keeling curve, and is an essential piece of evidence of the man-made increases in greenhouse gases that some believe to be the cause of global warming.

Hansen *et al* (2008) noted that, 350 parts per million is the safe upper limit of carbon dioxide in the atmosphere, above which the planet is in a state of climate crisis. To preserve our planet, scientists tell us we must reduce the amount of CO₂ in the atmosphere from its current level of 392 parts per million to below 350 PPM. The target posed by leading NASA climate scientist James Hansen of stabilising atmospheric carbon dioxide at 350 parts per million (PPM) is increasingly understood in conjunction with the need to keep cumulative emissions within a tight global “budget” . From a CO₂ concentration at the time of 385 PPM, Hansen argued, the level needed to be cut to 350 PPM at most.

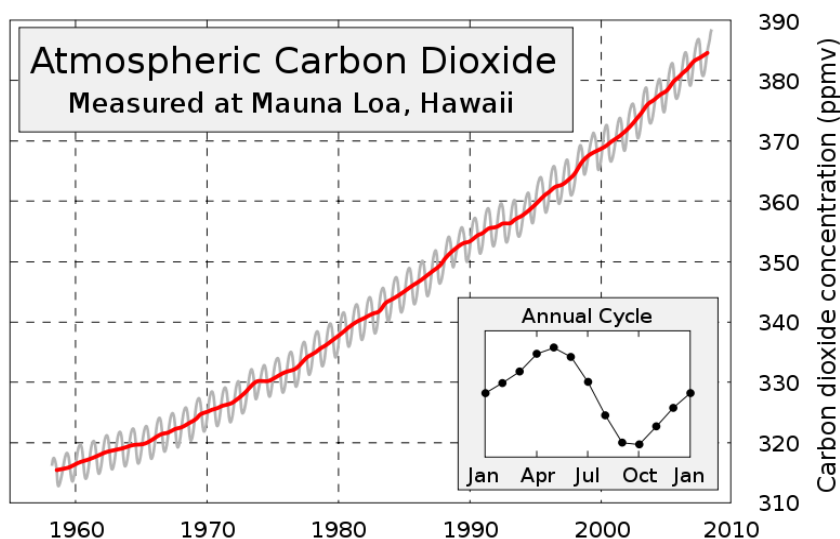


Figure 1.1: Atmospheric Carbon dioxide measured at Mauna Loa, Hawaii:Source: 350.org, (2011)

11.2 LITERATURE REVIEW

Hansen (2006) noted that 350 is the safe upper limit of carbon dioxide in the atmosphere, above which the planet is in a state of climate crisis. To preserve our planet, scientists tell us we must reduce the amount of CO₂ in the atmosphere from its current level of 392 parts per million to below 350 PPM. The target posed by leading *National Aeronautics and Space Administration* (NASA) climate scientist James Hansen of stabilising atmospheric carbon dioxide at 350 parts per million (PPM) is increasingly understood in conjunction with the need to keep cumulative

emissions within a tight global “budget” .

It is clear that global warming is happening faster than ever and humans are responsible (<http://www.350.org/en/understanding-350>). Most daily activities such as turning the lights on, cooking food, or heating or cooling at homes or travelling rely on the combustion of fossil fuels like coal and oil, which emit carbon dioxide and other heat-trapping gases when burned. Global warming destabilises the delicate balance that makes life on this planet possible. Just a few degrees in temperature can completely change the world as we know it, and threaten the lives of millions of people around the world.

Atmospheric concentrations of greenhouse gases are affected by the total amount of greenhouse gases emitted to and removed from the atmosphere around the world over time. Figure 2.1 shows a breakdown of global anthropogenic greenhouse gas emissions by each gas measured on a CO₂-equivalent basis.

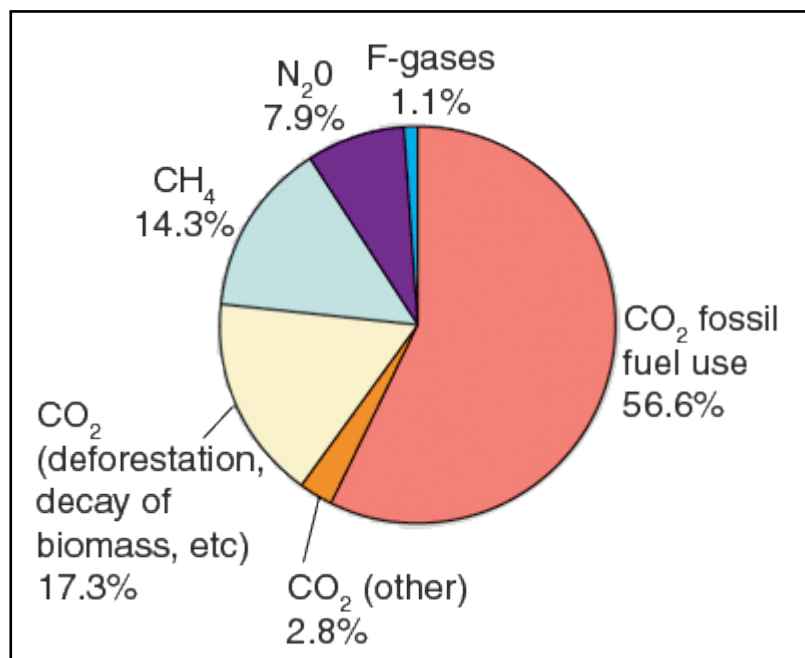


Figure 2.1: Global Anthropogenic Greenhouse Gas Emissions in 2004: **Source:** IPCC 4th Assessment Report: Climate Change 2007: Synthesis Report

It can be seen from figure 2.1 that the largest anthropogenic emission of carbon dioxide is from fossil fuel use. Transportation across the world accounts for the largest consumption of fossil fuel. The release of carbon dioxide through road transportation resulting from human activities is changing the amount of radiation coming into and leaving the atmosphere, likely contributing to changes in climate.

As automobiles are powered by fossil fuel, vehicular emissions constitute a threat both to the environment and global health in terms of climate change and air pollution respectively. According to the United Nations Environment Program (UNEP), over 600 million people are exposed annually to vehicular pollutants (Cacciola *et al*; 2002, UN, 1989). Pollutants released into the atmosphere from vehicles includes carbon dioxide (CO₂), carbon monoxide (CO), sulphur oxides (SO), nitrogen oxides (NO_x), particulate matter (particles of smoke, soot, and dust), hydrocarbons and lead (Corbitt, 1999). (National Research Council, 2010) published that carbon emissions from vehicles are a major source of atmospheric greenhouse gases (GHGs). In addition, the average emission per vehicle differs from one automobile to another (see figure 2.2).

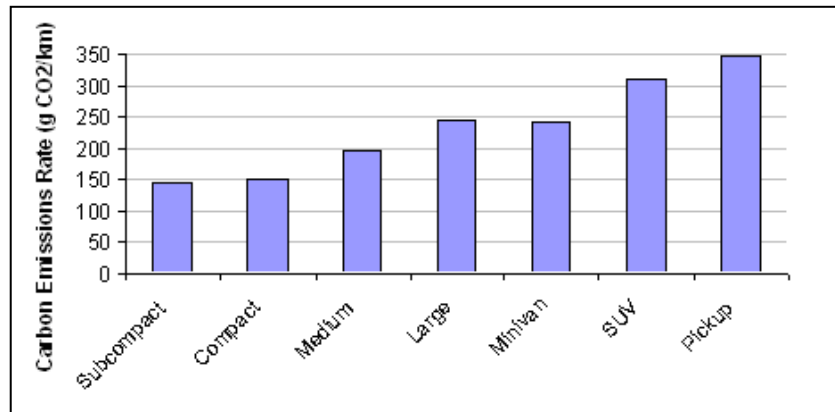


Figure 2.2: Average CO₂ Emissions Rates by Vehicle Type, 2002: **Source:** World Resource Institute (WRI) (2003)

It can be seen from figure 2.2 that emissions rate of vehicles is in proportional to the size of the vehicle type. The rate of emissions of CO₂ increases with the vehicle type size.

Gresham (2010) noted that carbon dioxide emissions (CO₂) from the combustion of fossil fuels must be reduced on a large scale to mitigate the effects of global climate change. Carbon Capture and Sequestration (CCS) has the potential to allow the continued use of fossil fuels with little or no emissions until alternative, low-to-zero emission sources of energy are more widely deployed. This study considered the legal and economic implications of securing the right to use geologic pore space-the microscopic space in subsurface rock matrixes-in an effort to sequester CO₂ deep underground to mitigate climate change. The findings and conclusions drawn in the study was intended to help guide discussion, research, and decision-making processes undertaken by policymakers and industry leaders with respect to the commercial-scale deployment of CCS. However, the question remains open as to whether the use of pore space for geologic CO₂ sequestration (GCS) is a trespass requiring compensation under the law.

Samaras (2008) pointed out that in order to mitigate the most severe effects of climate change, large global reductions in the current levels of anthropogenic greenhouse gas (GHGs) emissions are required in this century to stabilise atmospheric carbon dioxide

(CO₂) concentrations at less than double pre-industrial levels. The Intergovernmental Panel on Climate change (IPCC) fourth assessment report states that GHG emissions should be reduced to 50-80% of 2000 levels by 2050 to increase the likelihood of stabilising atmospheric CO₂ concentrations. In order to achieve the large GHG reductions by 2050 recommended by the IPCC, a fundamental shift and evolution will be required in the energy system. Because the electric power and transportation sectors represent the largest GHGs emissions sources in the United States, a unique opportunity for coupling these systems via electrified transportation could achieve synergistic environmental (GHGs emissions reductions) and energy security (petroleum displacement) benefits. Plug-in hybrid electric vehicles (PHEVs), which use electricity from the grid to power a portion of travel, could play a major role in reducing greenhouse gas (GHGs) emissions from the transport sector. However, the study established that the life cycle GHGs emissions from PHEVs depend on the electricity source that is used to charge the battery, so meaningful GHGs emissions reductions with PHEVs are conditional on low-carbon electricity sources.

McCoy (2008) stated that large reductions in carbon dioxide (CO₂) emissions are needed to mitigate the impacts of climate change. One method of achieving such reductions is CO₂ capture and storage (CCS). CCS requires the capture of carbon dioxide (CO₂) at a large industrial facility, such as a power plant, and its transport to a geological storage site where CO₂ is sequestered. If implemented, CCS could allow fossil fuels to be used with little or no CO₂ emissions until alternative energy sources are more widely deployed. Large volumes of CO₂ are most efficiently transported by pipeline and stored either in deep saline aquifers or in oil reservoirs, where CO₂ is used for enhanced oil recovery (EOR). The study described a suite of models developed to estimate the project-specific cost of CO₂ transport and storage. Engineering-economic models of pipeline CO₂ transport, CO₂-flood EOR, and aquifer storage were developed for this purpose. McCoy recommended that future research should include collection and aggregation of more specific data characterising possible sites for aquifer storage and applications of these models to this data.

Lemoine *et al* (2010) mentioned that biomass can help reduce greenhouse gases (GHGs) emissions by displacing petroleum in the transportation sector, by displacing fossil-based electricity, and by sequestering atmospheric carbon. They showed that bioelectricity's advantage over liquid biofuel depends on the GHGs intensity of the electricity displaced. Bioelectricity that displaces coal-fired electricity could reduce GHGs emissions, but bioelectricity that displaces wind electricity could increase GHG emissions. The electricity displaced depends upon existing infrastructure and policies affecting the electric grid. These findings demonstrate how model assumptions about whether the vehicle fleet and bioenergy use are fixed or free parameters constrain the policy questions an analysis can inform.

According to Ituah (2006), mobile source emissions have tended to be the largest contributor to urban emission inventories in many locations. It is instructive to note here that mobile sources tend to be much smaller, much more plentiful and much more widely dispersed than stationary sources. He further said that Environmental impact assessment (EIA) study carried out by Mechelec Construction (Nigeria) on behalf of

Lagos Urban Transport Project (LUTP) in 1996, the profile of air pollution by type and source, in Metropolitan Lagos, revealed that road traffic is the major source of air pollution. This is quite understandable since, over 60 percent of all activities are carried out using motor vehicles supported greatly by the use of two-stroke engine motor-cycles (“okada”) for public transport throughout the city. The study which is for a period of 14 months reported that at least half a million motor-cycle ply the nooks and crannies of the city. The problem has been exacerbated by the relatively high numbers of old and poorly maintained vehicles, which were imported into the country as fairly, used cars popularly known as “tokunbo cars”. The negative impact of all the associated emissions could be severe on the environment.

Schipper, Cordeiro and Ng (2007) published that all over the world, transportation projects are changing how people and goods move, with direct and indirect impacts on greenhouse gases emissions. Transport and environment officials, investors, and other stakeholders want to know how transport interventions will affect traffic, energy demand, and emissions. Estimating the impacts of projects involving fuel or technology switch is conceptually straightforward but still with its challenges regarding the reliability of available data and the capacity for data collection. Projects affecting modal share, load factors, origin and destination, number of passenger-kilometers driven, driving cycle and other parameters are a more complex proposition. Without reasonable measurement of results, decision makers hamper their ability to design effective control strategies and to monitor progress. The study presented an overview of the challenges frequently encountered when estimating the impact of transport projects on carbon dioxide emissions; described key approaches and methods commonly used; and provided examples from cities in Asia and Latin America. The study was based on literature review, consultation with experts in the transportation, energy and emissions fields and on experience in developing emissions estimations for projects interventions in developing country cities.

Barth and Boriboonsomsin (2009) explained that the surface transportation in the United States is a large source of greenhouse gas emissions, and therefore a large contributor to global climate change. Roughly a third of America’s carbon dioxide (CO₂) emissions come from moving people or goods, and 80 percent of these emissions are from cars and trucks. To reduce CO₂ emissions from the transportation sector, policy makers are primarily pushing for more efficient vehicles, alternative fuels, and reducing vehicle miles traveled (VMT). Policy makers have placed less attention on reducing CO₂ emissions by reducing traffic congestion. They also stated that as traffic congestion increases, so too do fuel consumption and CO₂ emissions. Therefore, congestion mitigation programs should reduce CO₂ emissions. The key question is how big of an emissions reduction we can get by reducing congestion. This question is difficult to answer, because CO₂ emissions, and the fuel consumption that causes them, are very sensitive to several factors. They concluded that although many people understand that driving contributes to greenhouse gas emissions, the measurement of this phenomenon has been surprisingly crude, often associating carbon emissions only with trip distance, without accounting for how carbon emissions change with vehicle speed.

11.2.1 Carbon Dioxide (CO₂) and the Vehicular Emission

In practice, a complete combustion of petrol produces mainly carbon dioxide (13%) and water (13%). Nitrogen from the air comprises most of the remaining exhaust, (73%). A very small portion of the nitrogen is converted to nitrogen oxides and some nitrated hydrocarbons. This implies that a larger percentage of the tailpipe exhausts are Carbon dioxide and carbon monoxide (Pedersen *et al*, 2003). Motor manufacturers in Europe are trying to increase fuel efficiency and consumption in order to reduce CO₂ emissions.

11.2.2 Vehicular Emission Regulation in Nigeria

At present, there is a legislative framework to monitor emission from mobile sources by the National Environmental Standard Regulation Enforcement Agency (NESREA) aimed at controlling emissions from mobile sources. While the existence of this legislation is worthy of commendation, the enforcement is still weak like most other laws in Nigeria.

11.3 RESEARCH METHODOLOGY

11.4 Field Procedure and Data Acquisition

11.4.1 The Site Selection And Identification Of Coordinates Identification Using Global Positioning System (GPS)

The road junctions used for data collection were selected and identified in each of the three locations of interest in the topographic maps of the study area. The street location of each road junction selected was also recorded within the study area. Furthermore, the coordinates of the selected and already identified road junction sites were collected. This phase of the research work commenced after the completion of the site selection phase. The essential equipment used in the phase of this research work was the hand-held Global Positioning System (GPS) unit. Other hardware equipment used for this stage of research method are a high speed laptop computer for word processing of texts and analysing all data captured and a Global Positioning System (GPS) device for spatial data capture. The database shows the GPS values in the Universal Transverse Mercator (UTM) for the sampled junctions.

11.4.2 Digitizing the Topographic Map and Developing the Database

The digitisation of the study area map was done and overlaid on a satellite image of the study area. Map Source software was used for downloading GPS data and ArcGIS for digitising the topographic maps of Minna, Bida and Suleja for database development. The development of the database of the selected sites containing both spatial and attribute data as it relates to the measured vehicular carbon dioxide emission was done. All data were recorded in the data log sheet. The complete detailed datasets of this research work are shown in the appendices A, B and C for Minna, Bida and Suleja respectively.

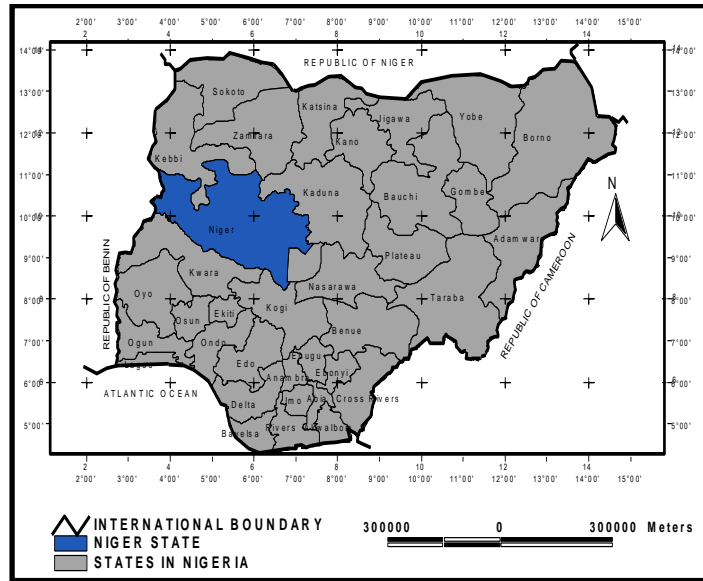


Figure 3.1: Location of Niger State, Nigeria: **Source:** Adapted from www.wadoo.org (2012)

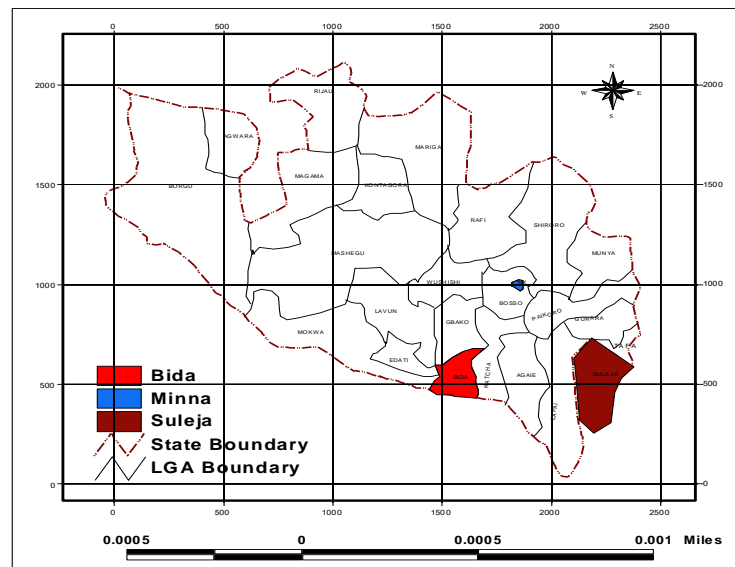


Figure 3.2: Locations of Minna, Bida and Suleja in Niger State: **Source:** Adapted from <http://nationalmirroronline.net> (2012)

11.4.3 Data Collection

Gasman carbon dioxide gas meter was used to take the carbon dioxide emission readings for this project work. The readings in Parts per Million of carbon dioxide emissions were obtained through the use of the gasman carbon dioxide meter for the peak and off-peak periods of vehicular movement at the pre-selected sample road junctions.

Traffic counts were also taken at these junctions to provide data to check for correlation between the emissions levels of carbon dioxide recorded if any. This was done for the off peak and peak traffic flow periods at these junctions according to the time the emission level readings were taken.

11.4.4 Data Analysis

Bar chart graphs plotted by plotting the emissions level of carbon dioxide as recorded on the field against the scientifically established internationally accepted safe limit of 350 Parts per Million of carbon dioxide in the atmosphere to curb global warming. Further statistical analysis was also carried out on the data recorded from the field. This was done by carrying out statistical tests. The software used for the statistical analysis is the Statistical Package for Social Sciences (SPSS) software. The statistical tests carried out with the SPSS software are linear correlation regression analysis and Analysis of Variance (ANOVA). The statistical test results reveal to what extent carbon dioxide emission is dependent on traffic volume. The tests also show the variance of the emission levels across each of the locations of interest in the study area.

Correlation determines the relationship existing between two variables. In the case of this study, the variables are the carbon emission levels and the corresponding traffic volume counts for each sampled station. For perfect correlation between variables, the R value should be 1. This means all values for the relationship between variables tends to 1. This means all values for relationship between variables tends towards 1, the closer the correlation coefficients to 1, the stronger the relationship between the variables. Negative correlation coefficient means the variables are not correlated i.e. there is no relationship. Statistical Package for Social Sciences (SPSS) software was used to compute the correlation between the traffic volume and the measured gaseous emission values of carbon dioxide using Pearson Correlation 2- tailed test at 0.01 decimal place significant levels.

The analysis results will also compare the average emission levels for the three locations of interest in the area. This will reveal which of the locations chosen as study area recorded the highest and lowest average emission levels of carbon dioxide from its road transportation. An Arc GIS presentation of the emissions variations and analysis will also be made for presentations at a glance.

11.5 RESULTS AND DISCUSSION

11.5.1 Results

Appendices A, B and C contains the raw data of the field work conducted in Minna, Bida and Suleja respectively to determine the emission levels of CO₂. In each of the towns, a total of 96 data counts were recorded, from which analysis of the emission level of CO₂ was based upon. The 96 data counts range from peak to off-peak period, which corresponds to the rate of flow of transportation vehicles. The variation in the rate of traffic flow at peak and off-peak periods subsequently resulted in variations in the value of the readings obtained, with peak periods having higher emission levels than off-peak periods. The analysis was individually carried out in each town with reference to the international safe limit of CO₂ emission in an environment (350 PPM)

and comparatively to determine the level of significant difference existing between the wide ranges of data obtained in the study areas. The latter, entails the application of suitable statistical examinations at an appropriate level of significance.

11.5.1.1 Descriptive Statistics of CO₂ Emission Data Generated in Minna, Bida and Suleja

Tables 4.1, 4.2 and 4.3 represent a summarised description of the CO₂ emission data generated in Minna, Bida and Suleja respectively. More details about the data generated are also shown in Appendices A, B and C for Minna, Bida and Suleja respectively.

Table 4.1 Descriptive Statistics of CO₂ Emissions Data Generated in Minna

Parameter	Value
Mean	2688.542
Standard Error	42.5116
Median	2810
Mode	3050
Standard Deviation	416.5269
Sample Variance	173494.7
Kurtosis	6.338264
Skewness	-2.37921
Range	2000
Minimum	1200
Maximum	3200
Sum	258100
Count	96
Confidence Level (95.0%)	84.3962

Table 4.2 Descriptive Statistics of CO₂ Emissions Data Generated in Bida

Parameter	Value
Mean	2518.125
Standard Error	23.30307209
Median	2500
Mode	2450
Standard Deviation	228.3225442
Sample Variance	52131.18421
Kurtosis	0.144140262
Skewness	0.414743198
Range	950
Minimum	2110
Maximum	3060
Sum	241740
Count	96
Confidence Level (95.0%)	46.26244614

Table 4.3 Descriptive Statistics of CO₂ Emissions Data Generated in Suleja

Parameter	Value
Mean	2856.458333
Standard Error	28.94716117
Median	2880
Mode	2880
Standard Deviation	283.6230974
Sample Variance	80442.0614
Kurtosis	0.710814391
Skewness	-0.87947656
Range	1140
Minimum	2110
Maximum	3250
Sum	274220
Count	96
Confidence Level (95.0%)	57.46737937

11.5.2 Summary of the CO₂ Emission Data Generated in Minna, Suleja and Bida

From table 4.4, it can be observed that the highest average emission level of CO₂ is obtained in Suleja, followed by Minna, with Bida having the least average emission level.

Table 4.4 Summary of CO₂ Emission levels in the Study Areas

Groups	Count	Average	Variance
Minna	96	2731.146	78892.36
Suleja	96	2856.458	80442.06
Bida	96	2518.125	52131.18

11.5.3 Data Analysis

11.5.3.1 Graphical Analysis of CO₂ Emissions in Study Areas

Figure 4.1 shows the variations in the average emission levels of CO₂ between the three study areas. Suleja is having the highest average emission level of 2856.458PPM while Bida is having the least emission level of 2518.125PPM compared to the other two towns.

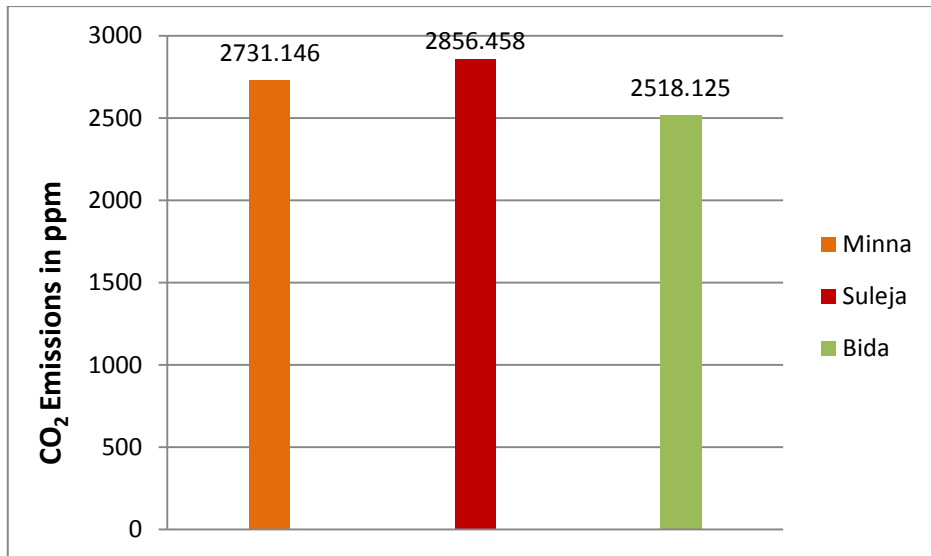


Figure 4.1: Average Emission Levels of CO₂ in the Study Areas

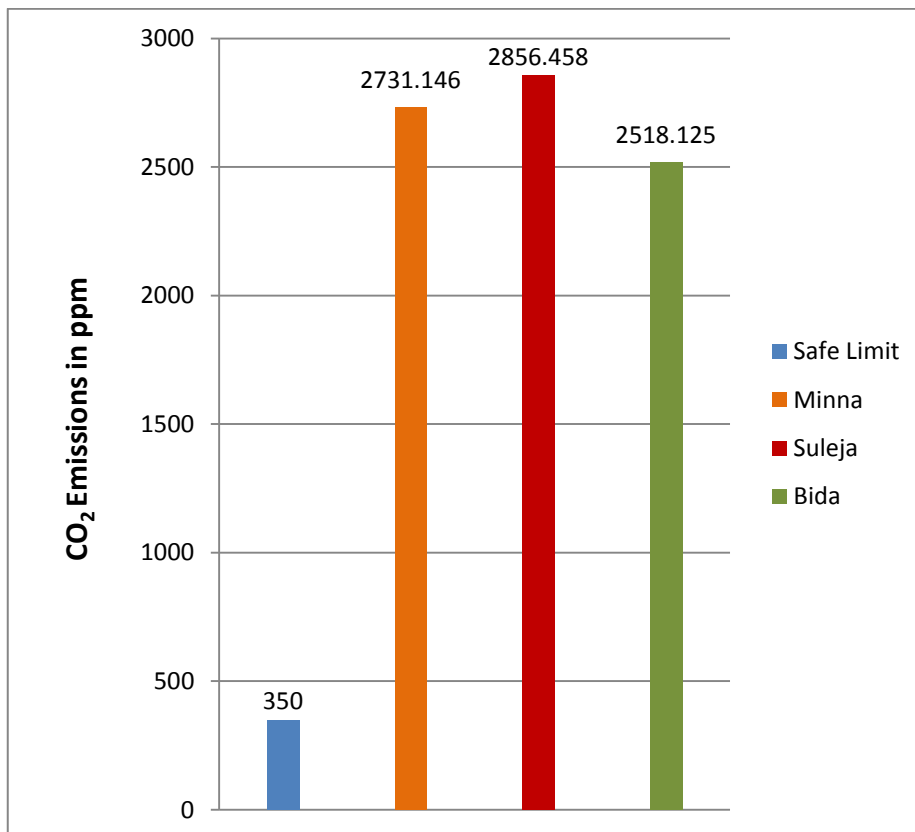


Figure 4.2: Deviation of Average Emission Levels of CO₂ in Study Area from the Internationally acceptable Safe Limit.

It can be observed from figure 4.2 that the average emission levels of CO₂ in the study areas deviate by more than five times from the internationally acceptable safe limit of 350PPM. This entails that the study areas are also contributing to the global phenomenon of climate change through CO₂ emission.

11.5.4 Statistical Analysis of the CO₂ Emission Data

11.5.4.1 Analysis of Variance (ANOVA) of the three CO₂ Emission Samples

ANOVA entails the testing of hypothesis on the means of three or more population sample, making use of the degree of variability (measure of variance), within each sample as well as between the samples, taken independently from these populations. The primary aim of ANOVA between population samples is to hypothetically test for significant difference between the population samples. Since the emission samples in Minna, Suleja and Bida comprises of just a single factor (CO₂), a Single Factor ANOVA (ANOVA One Way) was used to analyse the three population samples of CO₂ emission. The analysis provides a test of the hypothesis that each sample is drawn from the same underlying probability distribution against the alternative hypothesis that underlying probability distributions are not the same for all samples.

Table 4.5: Single Factor ANOVA between the CO₂ Emission Sample Data

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	5617617	2	2808809	39.84774	5.5E-16	3.027443265
Within Groups	20089232	285	70488.53			
Total	25706850	287				

From the foregoing analysis, table 4.5, shows the summary of a single factor ANOVA on the three samples of emission data at 0.05 significant levels. The analysis was carried out based on a null hypothesis that there are no significant differences between the means of the three CO₂ emission samples under the assumption that the variances of the three samples are all equal. The alternative hypothesis is that there is a significant difference between the means of the emission samples. The purpose of the analysis is to statistically accept the null hypothesis while the alternative hypothesis is rejected or to reject the null hypothesis while the alternative hypothesis is accepted.

From the summary table of the ANOVA analysis in table 4.5, it can be observed that the computed value of F (39.84774) is greater than the critical value of F (3.027443265); this sets up a critical region for the analysis i.e. a region for rejecting the null hypothesis. In other words, since the computed value of F is greater than the

critical value of F (*F crit*), we reject the null hypothesis and accept the alternative hypothesis. Thus, there is a significant difference between the means of the three emission samples at 0.05 significant levels.

This difference is justifiable qualitatively due to the variation in the traffic conditions in Minna, Suleja and Bida. The variation in traffic condition is due to the differences in the commercial and industrial activities of the towns. In ascending order, commercial and industrial activities in the three towns vary as follows, Bida, Minna and Suleja.

11.5.5 Correlation between the Three CO₂ Emission Samples

Correlation analysis measures the relationship existing between two or more data samples. This relation is determined by the establishment of a scaled factor called correlation coefficient from which the relationship is measured. The correlation coefficient is a measure of the extent to which two measurement variables "vary together". The correlation coefficient is scaled so that its value is independent of the units in which the two measurement variables are expressed. The value of any correlation coefficient must be between -1 and +1 inclusive. Correlation coefficient of +1 represents a condition of perfect correlation (perfect relationship) while correlation coefficient of 0 represents a condition of no correlation (no relationship). The result of the correlation analysis carried out between the three data samples is presented in the table 4.6.

Table 4.6: Correlations between the three samples of data

Location	Parameter	Minna	Suleja	Bida
Minna	Pearson Correlation	1	.348**	.390**
	Sig. (2-tailed)		.001	.000
	N	96	96	96
Suleja	Pearson Correlation	.348**	1	.057
	Sig. (2-tailed)	.001		.579
	N	96	96	96
Bida	Pearson Correlation	.390**	.057	1
	Sig. (2-tailed)	.000	.579	
	N	96	96	96

From the results above it can be seen that the relationship between the CO₂ emission in Minna is somehow related to the emission level in Bida since the correlation coefficient between them is 0.39; but the relationship between the emission levels in Suleja and Bida is very wide since the correlation coefficient between them is 0.057. Also, there is a relationship between the emission level in Suleja and Minna, but the relationship is less than that existing between Minna and Bida. This is seen with the correlation coefficient between Suleja and Bida less than that between Minna and Bida. i.e 0.348 is less than 0.39.

11.6 CONCLUSION AND RECOMMENDATION

This research has established the presence of CO₂ from vehicular emissions in the study area. The research clearly indicates the high level of the presence of this greenhouse gas in the atmosphere of the research area at an average level exceeding the internationally acceptable safe limit of 350PPM in the atmosphere. The study also shows the variations in the average emission levels of CO₂ between the three study areas. Suleja is having the highest average emission level of 2856.458PPM followed by Minna with 2731.146PPM while Bida is having the least 2518.125PPM.

Furthermore, these differences in emission level is due to the nature of economic activities in individual towns. Suleja having highest emission level is characterised with the highest commercial activities and this is prominent with the high level of vehicle traffic usually experienced. Suleja is a neighbouring town to Abuja the Federal Capital Territory and most of the workers in Abuja live in the town. Thus, there is always a scenerio of high traffic conditions at the morning and evening peak period and consequently accounts for the high level of vehicular carbon dioxide emissions. Bida having the least CO₂ emission is due to a lower level of vehicular traffic condition resulting from lower economic activities compared to Minna and Suleja. From a study carried out earlier by Ndoke *et al* (2006), the average emission levels recorded at locations in Kaduna and Abuja shows higher values of carbon dioxide concentration for heavily congested areas: 1840 PPM for Sabo, Kaduna, 1780 PPM for Stadium roundabout, Kaduna, and 1530 PPM for A.Y.A. Junction, Abuja – and lower values of carbon dioxide concentration for areas with minimal traffic – 1170 PPM for Jabi road, Kaduna, and 1160 PPM for Asokoro (behind ECOWAS), Abuja.

Although the study areas are not highly industrialised towns, the research has depicted the hazardous condition expected in highly industrialised towns since the level of CO₂ in such areas would definitely exceed the average emission recorded in the study area. It is also obviously evident in this study that the level of vehicular emission of CO₂ increases with the rate of the traffic volume. This is evident in Suleja which has a greater traffic volume compared to Minna and Bida having a corresponding greater average emission level of CO₂. With the internationally acceptable safe limit of CO₂ in the atmosphere to be 350PPM, the average emission levels of CO₂ in the entire study areas is of great concern on the global warming implications. However, according to Greiner (1995), this emission quantities are not high enough to cause health hazards but as vehicular traffic grows in number and age, the quantity of carbon dioxide that will be released in the near future in these study areas will be enough to make the government of the day worry.

The research has clearly shown that Minna, Bida and Suleja are largely contributing to the high level emission of CO₂ globally via road transportation; thus, contributing to the global phenomenon of climate change and the recommendations from this study are as follows:

- Introduction of the urban mass transit would definitely reduce the number of traffic on the roads, hence the emissions from several vehicles that would have been on the road. This would also be a cheaper means of transportation for the masses.
- Encouraging the use of vehicles using alternative sources of energy like solar, electric and biofuel will also result in less emission levels as these alternative energy sources other than fossil fuel originated diesel and petrol vehicles do not emit especially carbon dioxide.
- Research programs should be initiated to come out result providing alternative sources of fuels whose final products would not emit greenhouse gases.
- Afforestation programs should be put in place by the government to help salvage the environment by absorbing CO₂ being emitted.

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12 Effect of Rate of Energy Consumption of Construction Materials Specified by Features of Surfaces Aiming to Reduce Energy Consumption

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Abstract: As earth's climate changes and its gradual warming are very serious, these phenomena have been studied by specialists and experts for a long time. While these issues are under the influence of different factors, it is necessary to collect the viewpoints from different scientific fields of study to offer a suitable approach. It is quite evident that some studies should be carried out on these issues since buildings play a major role in producing greenhouse gasses, which leads to earth's climate changes. By focusing on surface features of construction materials, the present research provides useful points on building reconstruction and future constructions. Surface features of construction materials in terms of quantity and type of surface depression, porosity, and color have direct effects on consuming the required energy for washing, maintaining and providing light during the operation period. Therefore, the present study principally aims at studying energy consumption rate of each type of construction material focusing on different features of surfaces. Being aware of the effect of porosity of construction materials considerably helps the selection of floor construction and frontage materials. The amazing effect of this point would be obvious when the savings obtained from selecting the type of materials are added to the energy saved as a result of reconstruction rather than destruction. The methodology includes both desk and field study so that the primary studies were carried out by desk method to obtain basic information. Then, the information needed for evaluating the relationship between building materials and energy consumption was collected by field case studies.

Keywords: Coefficient of Energy Consumption, Global warming, Surface features of construction materials, Reduce Energy Consumption

12.1 INTRODUCTION

The climate changes of earth and the gradual global warming are problems which have been considered and investigated for a long time by authorities and experts due to their great importance. According to the evaluations of member scientists of UN meteorology research group, the temperature of the earth will raise about 1.4 °C to 5.6 °C by the end of the current century (Farshchi , 2009). Although this raise seems not to be numerically significant, it is important because it progressively continues to rise every year. According to the researches done by British scientists, the global warming trend would be at least 50% faster than predicted which will ultimately result in destructive impacts on earth and will threaten human life and urbanity (Azizi , 2008).

If we call the chain-like impacts of the global warming on environment as climate change, providing some measures for decreasing the negative impacts of this phenomenon seems necessary. Since various factors affect this phenomenon, it is necessary to collect the idea of different sciences in order to offer appropriate solutions.

Studying the effects of material change on reducing the energy consumption, this

paper is presented in three separate sections. The first section investigates the effect of construction industry on global climate change as well as the contribution of this domain in greenhouse gas emission rate. The second section concentrates on the trend changes of energy consumption in architecture from past to present and classifying different kinds of energy consumption in buildings, it distinguishes the maximum distinction in energy consumption rate from past to present. Finally, in the third section, the results derived from the studies on relation between different building materials and energy consumption are introduced.

12.2 RESEARCH METHODOLOGY

The methodology includes both desk and field study so that the primary studies were carried out by desk method to obtain basic information. Then, the information needed for evaluating the relationship between building materials and energy consumption was collected by field case studies.

In order to evaluate the rate of energy consumption as well as using the building materials, 5 types of building located at the same climate (Shiraz, Iran) were selected. It should be noted that the accuracy of results depends on the compatibility of selected buildings, thus the samples were selected among 4-story, 6-8 unit apartment buildings with approximately same area. The compatibility of following items was considered in case selection as well:

- Number of residents in each flat
- Life style of residents
- Consumption culture of residents
- Using the same heating and cooling devices

12.3 Climate and Buildings

12.3.1 Climate change and buildings

The most important solution to prevent further climate change remains in attention to energy issue. In this regard, the policy makers should prepare motivating or inhibiting plans aiming at decreasing the use of fossil fuel or investing in more efficient energy technologies.

The major part of energy is consumed in three sections: Building, transportation and agriculture & industry. Table 1 shows the rate of energy consumption in each section in three different countries.

Table 1: Energy consumption quota in different sectors (Farshchi , 2009)

Industry & Agriculture	Transportation	Construction	
41	25	34	USA
45	20	35	England
15-20	30	45-52	Iran

The above table reveals that the main part of energy is consumed in building section. This rate is surprising in the developing countries like Iran. The energy consumption rate is considerable in other countries as well.

Emission of GHG (Greenhouse Gas) is directly associated with the consumption of fossil fuels. Given the cities consume more than 50% of energy, of which 45% is consumed by buildings, (Azizi , 2005) any measure adoption aiming at saving and reducing the energy consumption in cities and buildings will finally result in the reduction of GHG emission which in turn will prevent the current trend of climate change.

12.3.2 Buildings Energy Consumption

The idea of architecture styles in different periods in Iran has had significant impact on the energy consumption rate. Sustainable or the climate adapted architecture is an idea emphasised by experts due to its contribution in reduction of energy consumption. Five principles of Iranian traditional architecture styles accommodate these climate ideas such as using the locally available materials and designing the building height considering the local climate condition. Given Iran's largest area consists of dry lands, its traditional architecture offers appropriate solutions to such condition including louvers, ice houses, water reservoirs and so on which obtain their energy via renewable resources, but increasing the use of fossil fuel powered heating and cooling devices in buildings pushed the architecture into the international styles and apartment buildings. Energy consumption in buildings is divided into two groups:

- I. constructional activities including the direct and indirect use of energy

Direct use:

- machineries and building tools
- transportation including man and material transportation
- constructional activities

Indirect:

- manufacturing the machineries and tools in factory
- transportation vehicles in factory
- production of materials in factory

This category includes other direct and indirect types of energy consumptions too vast to be discussed in this paper. Regarding the aforementioned issues about the energy

consumption rate reduction in this section, this question is raised that is destructing the old buildings and constructing the new ones always the best solution? Is the renewal of buildings which have passed just less than half of their lifetime an effective approach with respect to energy saving issue? All of these questions require a separate study which cannot be included in the present paper.

II. Project Exploitation and Maintenance

Building maintenance always requires energy consumption but in the case the exploiting is accompanied with some architectural measures the rate of energy consumption will significantly decrease. In present time, these measures could provide an appropriate answer to the current climate conditions and limitations. One of the ideas considered in this study has been extracted from an Iranian traditional architecture principle which is using the locally available materials.

12.3.3 Energy Consumption and Building Materials

The majority of fossil energy loss is attributed to the typical and non-standard building patterns which take place during heating or cooling operations due to their inconformity with their climate conditions. Some measures have been also prepared for this purpose; for instance, the building materials are checked for their heat capacity.

Investigating the relationship between building materials and energy consumption, the present study examines the effectiveness of revealed theories. Table 2 shows the information about the consumption rate of water, electricity and gas energy in residential flats of approximately same area, number of residents and climate conditions. Each row indicates the mean consumption rate of a flat located in the middle stories of a 6-8 unite apartment.

Table 2: Energy consumption of different types of buildings

Gas use m3	Power Use kwh	Water Use Litre	Infrastructure M2	Area M2	Year of construction	
10	183.4	13000	100	120	1386	1
27	237.1	12100	100	125	1386	2
20	283.1	14000	160	180	1387	3
58	256,5	8010	150	175	1374	4
31	294,3	13500	165	183	1382	5

Table 3 shows the materials used in each building. According to the above mentioned issues, the heating and cooling process of a building plays a significant role in its rate of energy consumption. So the data collected from the selected buildings (see table 3) is based on the type of material used in their external walls. Walls are selected

because of the fact that the main part of heat transfer occurs through them for they are in contact with the outdoor air. Other building conditions effective on the results of this study have been selected uniformly as much as possible. For example, in order to eliminate the effect heat transfer through floor and roof, the energy consumption rate of the flats located in the middle stories of each building was examined. In addition to this, all flats have the same kind of floor and ceiling covering materials and use the same heating and cooling methods and systems.

Table 3: Energy usage and the materials used in each building

Gas use m3	Power Use kwh	Water Use Litre	Façade materials	Exterior wall materials	Type of Glass	
10	183.4	13000	Brick	Brick	Double	1
27	237.1	12100	Brick	Brick	Normal	2
20	283.1	14000	Cement	Brick	Double	3
58	256,5	8010	Stone	Common Brick(solid)	Normal	4
34	294,3	13500	Cement	Brick	Normal	5

The flats were compared in terms of the consumption rate of electricity and gas as the main heating and cooling sources in under study cases. Table 3 shows the impact of external wall materials on energy consumption rate, regarding the fact that the flats are the same in other conditions. Building No. 1 with double pane glass windows and external brick walls has the minimum rate of energy consumption (heat transfer is lower in Brick due to its higher heat capacity). Building No. 3 has double pane glass windows as well and with respect to its area, which is more than other cases, it had lower rate of energy consumption. Among all studied cases, building No. 4 had the maximum energy consumption. Therefore, the general condition of external walls of all selected buildings was rechecked. The main reason creating such a difference is the percentage of openings (windows) on the external walls of the building No. 4 which was 80% of the wall.

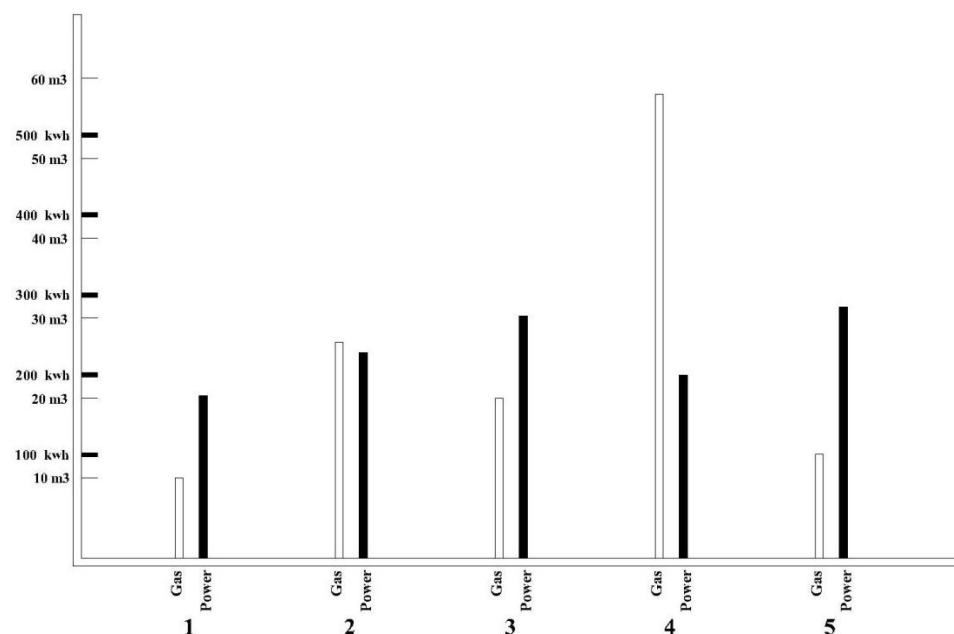


Figure 1: (Authors , 2011)

Water was the third type of energy studied in the selected cases. Water is mostly used for washing and drinking purposes in buildings and usually plays a negligible role in heating and cooling. Meanwhile, the amount of water used for drinking is very low and negligible which means that the majority of water is used for washing purposes. Thus, the washable surfaces have been studied in terms of their porosity.

Table 4 shows the area (m²) of outdoor spaces which are more likely subject to pollution including the yards, terraces, parking and so on. The kitchen and bathroom areas are not taken into account because of having the same condition.

Table 4: Area (m2) of outdoor spaces which are more likely subject to pollution

Type of Depth	joint
Depth of joint	Joint (type no.1)
Less than 1mm	
Depth of joint	Joint (type no.2)
Between 1-3 mm	
Depth of joint	Joint (type no.3)
Between 3-5 mm	

In the cases where the flooring materials have no considerable difference in their surface porosity, they could be ignored. Flooring methods are divided into three groups regarding the depth of joints (see table 5).

Table 5: Flooring methods and energy consumption

Joint (type no.3)	Joint (type no.2)	Joint (type no.1)	Water Use Litre	Patio M2	
	*		13000	20	1
	*		12100	25	2
*			14000	20	3
		*	8010	25	4
*			13500	18	5

The results of investigations on the relationship between the water consumption rate and the type of joints in the surfaces subjected to pollution which needs to be washed frequently are shown in Graph 2.

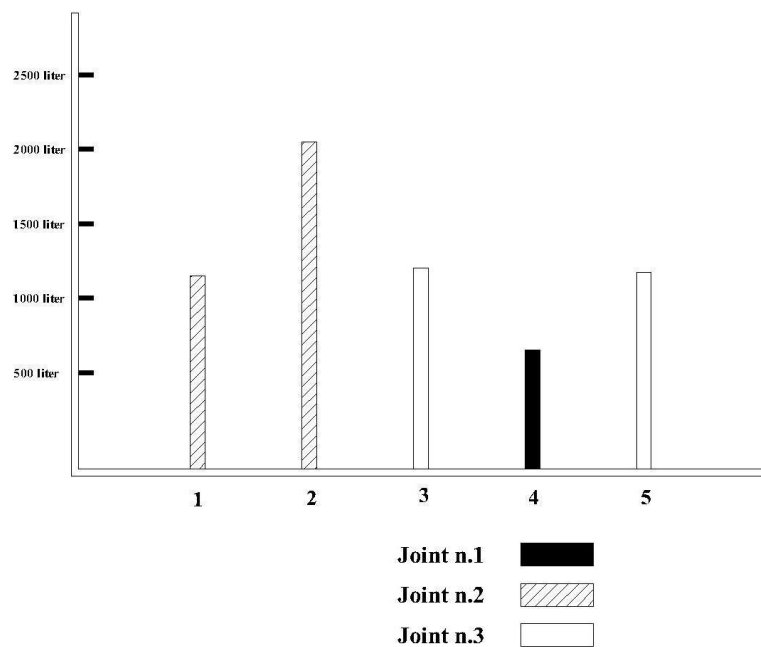


Figure no.2 (Authors , 2011)

The building No. 4 is the only case in which a low depth grout joint have been used in

flooring. This building has significantly lower water consumption rate (for washing purposes) compared with other buildings.

12.4 CONCLUSION

The findings of carried out study are as follows:

- Double pane glass windows are more effective than typical windows in decreasing the rate of energy consumption in the same condition.
- Using brick in dry climates as well as the other climate compatible materials reduces energy consumption.
- Simultaneous use of climate compatible materials and double pane glass windows is more effective in reducing the energy consumption.
- The window-to-wall ratio of building has an effect in energy consumption. The more the ratio is, the higher the energy loss is.
- The type of joints and flooring in outdoor open spaces is effective on energy consumption. The joint depth is directly proportional to the energy consumption.

If the above mentioned measures about external walls and the other optimising factors are observed in buildings, investigating these optimum groups in different climates, we can obtain a range of energy consumption as an international standard for future buildings which requires another study In line with the present study.

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13 Effect of Changing Flow Rate on Habitat Suitability of Tinfoil Barb in Upstream Langat River Using CASiMiR Model

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Abstract: The habitat suitability of freshwater species and ecosystems should also be considered in every attempts made to manage water to meet human requirements. River hydraulics and geometry has direct effect on habitat suitability in rivers and fish is used as a measure for this suitability. CASiMiR model (Computer Aided Simulation Model for Instream Flow Regulations) is a new model which is proposed to be used to assess suitability of rivers habitat. In this study, CASiMiR model is used to assess the habitat suitability for Langat River, Selangor, Malaysia by taking one stretch of 200 m at upstream. Fuzzy models were developed by an experienced fish expert for the selected fish species which called *Tinfoil Barb* in its two different life stages (adult and juvenile). Two indices were used to assess the habitat suitability and these are Weighted Usable Area (WUA) and Hydraulic Habitat Suitability (HHS). The current study on habitat modelling was the first time applying in Malaysia and the model analysed the relationship between flow rate and physical habitat as defined by the combination of depths, velocities and substrates found in the selected reach of Langat river. Therefore additional factors influencing habitat conditions such as geomorphological changes, seasonal changes in aquatic vegetation, water quality and temperature were not investigated within this study. Based on the computed indices, the highest habitat suitability for adult of Tinfoil Barb was found at high flow rate of 10.65 m³/s at upstream indicating almost good habitat suitability for this life stage which increases when the flow rate increase during the year. On contrary and for juvenile life stage, the habitat suitability was found in low flow rate of 1.3 m³/s. Juvenile benefits more when the flow rate is low.

Keywords: Langat River, Habitat Suitability, CASiMiR Model, Tinfoil Barb, Fuzzy Logic

13.1 BACKGROUND OF THE STUDY

Following the increase in water demand of the mid-20th century, biologists and hydrologists recognised the need for ‘instream flows’ to protect fish and aquatic habitat (Stewart et al., 2005). Instream flow refers to water that is retained in a river after human actions such as impoundment or diversion for out-of-stream use by industry, agriculture, etc. Rivers are valuable for maintaining fish and wildlife habitat. This has led to the provision of rivers specifically for environmental purposes. These are designed to enhance or maintain the habitat for riparian or aquatic life. The need to sustain the ecological values of rivers is now widely recognised and implemented in different policies and legislations around the world. Generally speaking, these legislations insist on maintaining sufficient flow in a river to allow different species (mostly fish) to successfully complete their different life stages (Leclerc et al., 2003).

Habitat requirements can be defined as environmental features necessary for the survival and persistence of individuals or populations (Armstrong et al., 2003; Rosenfeld, 2003). Physical habitat structure is of paramount importance in determining both the abundance and species composition of stream fishes, thus most habitat

studies deal only with physical variables. The physical habitat characteristics mostly considered in this context include water depth, water velocity and flow discharge.

The habitat suitability index (HSI), the most commonly used index of habitat, is an analytical tool used to represent preferences of different species for a combination of instream variables (e.g. velocity, depth, substrate, cover) (Heggenes, 1990). In general, the indices are in the range of 0 – 1 for each variable. Several suitability indices must be combined to define a composite suitability index.

Many factors influence the health of river ecosystems including temperature, oxygen, light, geomorphology and flow (Hynes, 1970; Giller and Malmqvist, 1998; Norris and Thoms, 1999). A holistic approach must therefore be taken for the long-term management of river systems, which considers how human activities impact upon interactions between factors such as geology, sediment transport, channel structure, riparian conditions, water quality and biological habitat. However, apart from through dilution effects, flow rate is only a surrogate variable; it is the water depth and velocity in a river, created by the interaction between flow rate and channel morphology, that provides physical habitat for plants, invertebrates and fish. Jowett (1992) found that the amount of physical habitat was an important determinant of trout abundance; Gore et al. (1998) found relationships between physical habitat and actual benthic community diversity; and Gallagher and Gard (1999) found a positive correlation between physical habitat and spawning density of salmon.

The direct relationship between physical habitat and flow provides a means for assessing the ecological impact of changing the flow regime of a river (Beecher et al., 1993). However, assessment of river flow management options often involves assessing scenarios that fall outside the range of observed conditions, and thus predictive models are required. The Physical Habitat Simulation (PHABSIM) system (Bovee, 1982; Bovee et al., 1998) was the first systematic modelling framework to be developed and many models based on a similar concept have been produced including CASiMIR in Germany (Jorde, 1996; Eisner et al., 2005), EVHA in France, RHYHABSIM in New Zealand and RSS in Norway. Essentially these models quantify the relationship between physical habitat, defined in terms of the combination of depth, velocity and substrate/cover, and various flows. PHABSIM in particular has become a legal requirement for many impact studies in the USA (Reiser et al., 1989) and a standard tool employed by the Environment Agency of England and Wales to define the sensitivity of rivers to abstraction (Booker and Acreman, 2006). RHYHABSIM has been applied to many rivers in New Zealand (Lamouroux and Jowett, 2005) for a variety of reasons. Jowett and Biggs (2006) reviewed the results from six rivers in which habitat-based methods had been applied to flow setting. They found that in five of these cases the biological response and the retention of desired instream values were achieved.

This study aimed to apply CASiMiR model to assess habitat suitability of Tinfoil Barb in its two different life stages (Adult and juvenile) in one selected river reach in Malaysia.

13.2 STUDY AREA

This study is conducted on one selected reach from Langat River, Malaysia. The size of Langat River Basin is approximately equal to 1815 km². The Langat River Basin

occupies South and South-Eastern parts of the state of Selangor and it has several tributaries with the principal ones being the Semenyih River, the Lui River and the Beranang River. The main reach of Langat River is passing the urban areas especially at the City of Kajang. One 200 m reach was selected from the upstream Langat River at the city of Kajang with a stream flow and water depth gauging stations on it. Also, the river geometry for this reach is available. The selected river reach at Kajang city was assessed for fish habitat suitability using CASiMiR model.

13.3 METHODOLOGY

CASiMiR model can be used to predict habitat availability and suitability for the native fish species. In this study, the model was used to simulate two dimensional river hydraulics based on riverbed topography, roughness, substratum type, flow discharge and water surface elevation at each cross-section for Langat River in the selected reach. Data used in this model were water flow rates, water levels and river cross sections. The above data was acquired from the Department of Irrigation and Drainage, Malaysia (DID) while the data on preferences of specified fish habitat under investigation was obtained from personal interview with a fish expert.

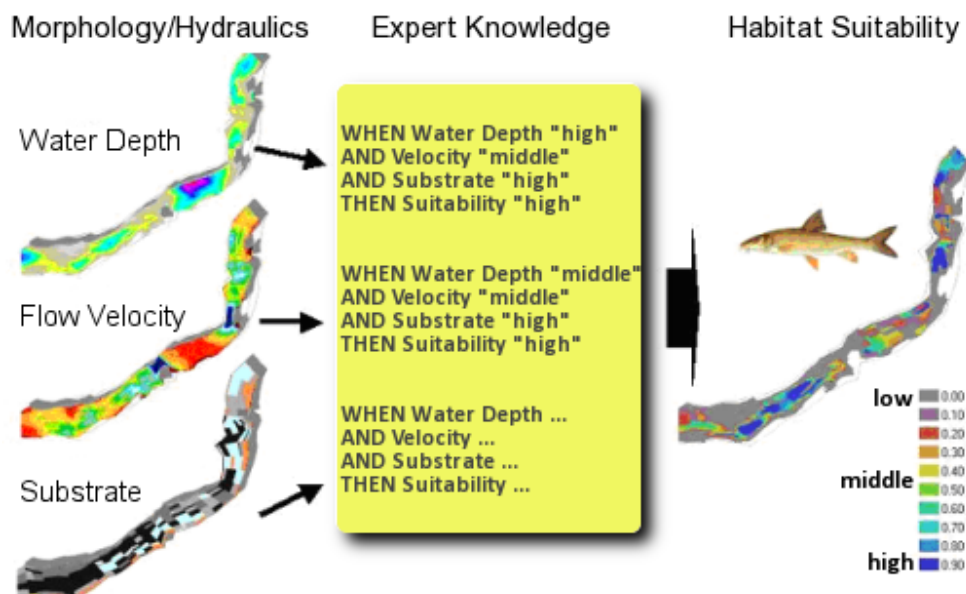


Figure 1: Principle of new fuzzy rule based approach used in CASiMiR
(Source: Handbook for the Habitat simulation Model, CASiMiR, 2010)

In this study, 26 cross sections were used in the modelling exercise. The cross sections were distributed along 200 m river reach length. The mean substrate diameters for the selected reaches were obtained from the Department of Irrigation and Drainage, Malaysia. Data of river bed samples show that the dominant bed substrate is clay, silt and sand.

The habitat suitability was simulated based on hydraulic conditions, fuzzy sets and fuzzy rules. For the habitat simulation, variables such as water depth, flow velocity and dominant substratum size are defined by fuzzy sets. Briefly, a fuzzy set is defined by its

membership function that gives a certain degree of membership for a variable value. Fuzzy sets are named with linguistic expressions that are commonly used by fish experts for the description of habitat preferences: Low (L), Medium (M), or High (H).

A fish expert has been asked to define the most likely consequence of habitat suitability for different combinations of input variables (i.e. substrate diameter, velocity and water depth). This involved indicating Low (L), Medium (M) or High (H) category for 27 combinations. *Tinfoil Barb* (Lampam Sungai in Malay Language) is one of the species found in Langat River and other rivers of Malaysia. This species is indigenous fish found in Malaysia, Indonesia, Thailand and China. It is found usually in rivers, streams, canals, ditches and flooded rice fields and it is economically important for human as a food fish and aquarium fish. The fuzzy models were thus developed for the *Tinfoil Barb* in its two different life stages, Adult and Juvenile.

The habitat suitability index (HSI), the most commonly used index of habitat, is an analytical tool used to represent preferences of different species for a combination of instream variables (e.g. velocity, depth, substrate, cover) (Heggenes, 1990). Habitat suitability is subdivided in three linguistic classes labelled low, medium and high. Modelling is processed as follows: with crisp input numbers from the hydraulic model (water depth, flow velocity) the fuzzy model first calculates the degree of membership of these parameters to the membership functions. In a next step, the degree of fulfilment (DOF) of each fuzzy rule is analysed. Then, the fuzzy sets of the output variable (HSI = habitat suitability index) are weighted with these DOF's and combined to a final fuzzy set. In a last step called defuzzification, the final fuzzy set is transformed back into a standardized crisp number to describe the habitat suitability index (HSI) which is defined between 0 (unsuitable) and 1 (suitable). Coloured habitat maps generated by the GIS based river-analysing system within CASIMIR explain the spatial distribution of the calculated habitat suitability index HSI. By using two indices namely, *Weighted Usable Area* (WUA) and *Hydraulic Habitat Suitability* (HHS), the habitat suitability is integrated over the whole area under investigation using the following formula,

$$WUA = \sum_{i=1}^n HSI_i A_i \quad (1)$$

where, n is the total number of grid cells, HSI_i is the habitat suitability index of a single grid cell and A_i is the area of the single grid cell. The index HHS is computed by using the following formula,

$$HHS = WUA / \text{Wetted Area} \quad (2)$$

For a river section with best habitat qualities the HHS is theoretically equal to 1.0 but if a river section provides no suitable habitats then HHS is theoretically equal to 0.0.

Color	SI
Gray	0
Purple	0.1
Red	0.2
Orange	0.3
Yellow	0.4
Light Green	0.5
Green	0.6
Teal	0.7
Blue	0.8
Dark Blue	0.9-1

Figure 2: Range of the habitat suitability index (SI)

13.4 RESULTS AND DISCUSSIONS:

The plan view of habitat suitability allows quick and convenient visualisation for the river reaches.

Equation (2) is used to determine the Hydraulic Habitat Suitability index (HHS). It is useful to describe the relationship between habitat quality and flow rate for Langat River for the given reaches. The WUA and HHS have been calculated for Tinfoil Barb in its two different life stages (Adult, Juvenile) at upstream of Langat River. Figures below show the variation of WUA and HHS with discharge for Langat River at upstream.

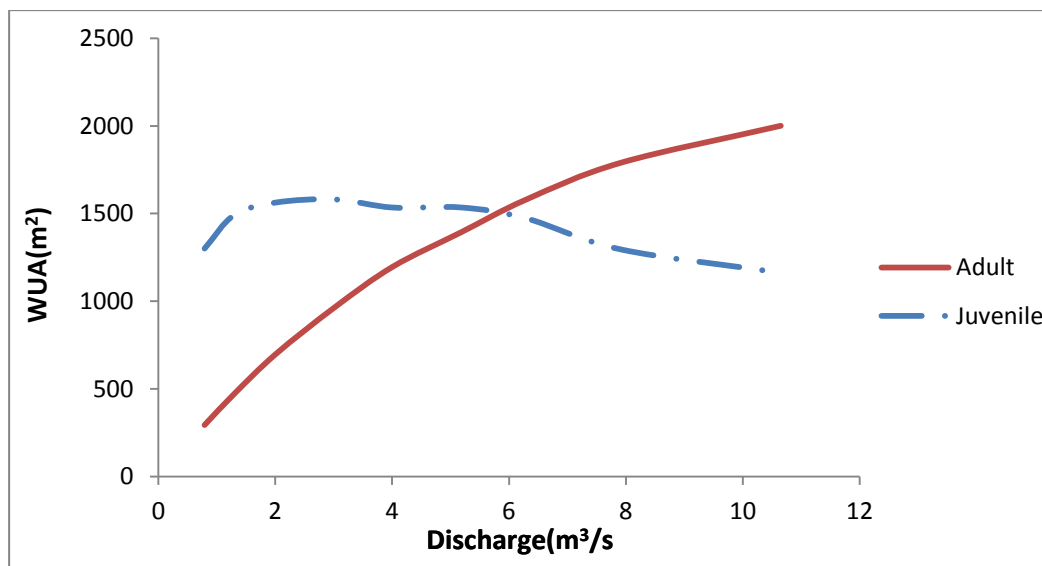


Figure 3: Weighted Usable Area (WUA) for Tinfoil Barb (Adult and Juvenile) at Upstream

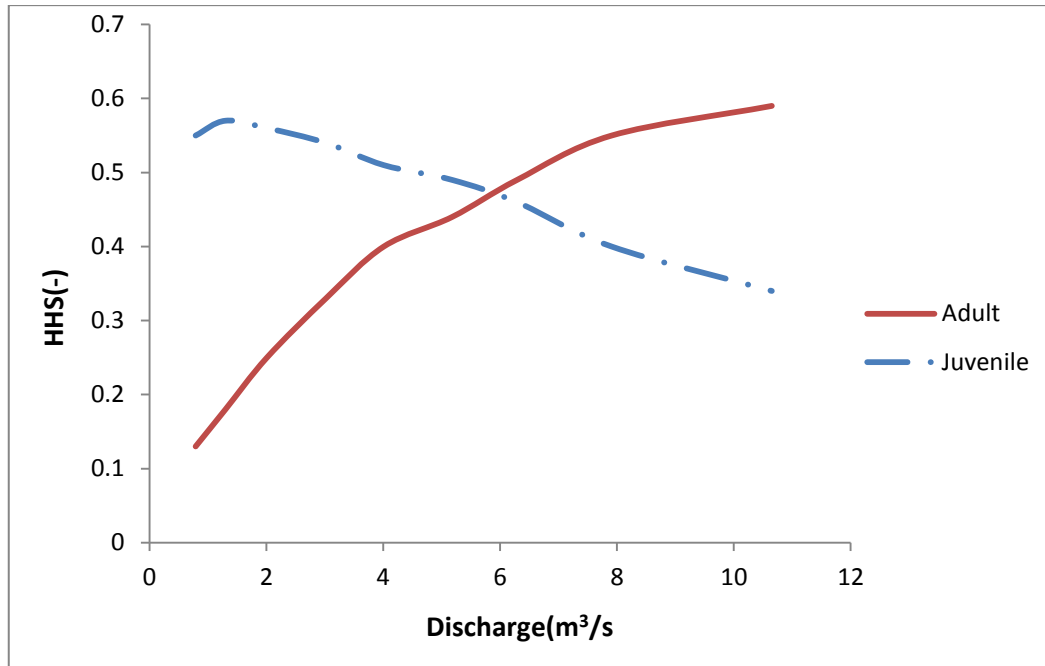


Figure 4: Hydraulic Habitat Suitability (HHS) for Tinfoil Barb (Adult and Juvenile) at upstream

From the above figures it can be seen that hydraulic habitat suitability increases as the flow rates increase. So the highest habitat suitability for the adult Tinfoil Barb can be found in the flow rate of $10.65 \text{ m}^3/\text{s}$ in Langat River at upstream. Other results show that habitat suitability is decreasing by increasing the flow rates for juvenile Tinfoil Barb. So, there is higher habitat suitability in low discharges. It can be seen that the best condition for this life stage is the flow rate of $1.3 \text{ m}^3/\text{s}$.

13.5 CONCLUSION

Improvement of the ecological conditions of surface waters tools for the assessment of these conditions are urgently needed for rivers in Malaysia. There is demand for new technologies, in particular forecasting instruments for the efficacy of engineering measures and consequently for their optimisation. Habitat modelling covers both of these aspects and by that applies to many different fields of water engineering and management. The new fuzzy-rule-based approach implemented in the simulation model CASIMIR is highly suitable for the investigation of ecological problems and has proven its practicability in various applications.

The variations of flow rates in relation to habitat suitability of the certain species are significant. The results of this study show the effect of changing flow rates on the habitability of *Tinfoil Barb* in its two different life stages in one reach of Langat River. However, modelling for the whole river basin would be useful and essential task for decision makers in relation to surface water resources and river restoration.

In current study, habitat modelling has been done for one selected reach of Langat River, Malaysia using CASiMiR model. The effects of changing flow rates during one

year on habitat suitability of *Tinfoil Barb* in its two different life stages have been studied.

Results show that the selected reach has almost good habitat suitability for adult Tinfoil Barb which increases when flow rates increase during the year. For low flow rates, habitat condition is not suitable for adult Tinfoil Barb. In contrast with adult life stage, juvenile benefits more during low flow rates.

Findings of this study can be used for improving the fish habitat at Langat River. Having understood how the suitability of habitat would be affected by flow rate changes, engineers and ecologists can work together to improve the ecological conditions of Langat River. The impact of dam operations and hydraulic structures on habitat suitability can be also simulated using CASiMiR model. This is very helpful for conservation of the environment particularly the river ecosystem.

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14 The Impact of Exurbanism on Infrastructural Facilities in Bangsar, Kuala Lumpur

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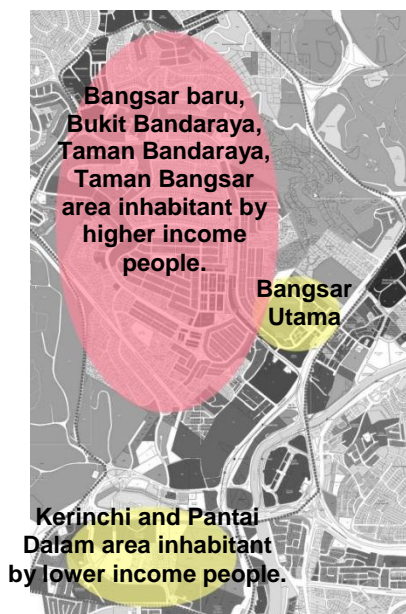
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Abstract: Exurbanism is influenced by the way a city is being planned. Besides, exurban form is also interrelated to the environment, functionality, and economic development, social and cultural structure of a city. This study will discuss the extent of exurb development in Bangsar, Kuala Lumpur. Theory-guided content analysis is applied where the initial presupposition in the analysis was that the subject matter of the study depicted the studied phenomenon. The purpose of the study was to investigate the exurbanism in Bangsar and seeks the relationship between exurbanism and permeability of infrastructural facilities. Hence, suitable planning of infrastructural facilities in terms of accessible roads to improve permeability in exurb Bangsar can be identified. The study produces a clear description of the phenomenon, and arrange in an organize form without losing the information contained therein. The study leads on how future Bangsar should look in the globalization age. Bangsar can be made more liveable with a better exurb living quality by fostering the cultural values and community lifestyles that creates the sense of place in the future.

Keywords: Exurbanism, Infrastructural Facilities, Kuala Lumpur, Malaysia.

14.1 INTRODUCTION

Bangsar is 4 kilometres south-west of the Kuala Lumpur city centre. It serves as a mature residential area principally for those in higher income group. Development of exurb infrastructure facilities cannot be viewed in isolation, and therefore a study is required to find out its relationship with exurb development. Planners of cities may overlooked and unprepared to address the special needs of exurb. This is because the tools and methods that planners refer and use to manage the exurb may devoid the understanding on the people living there. The exurban form is also interrelated to the environment, functionality, and economic development, social and cultural structure of the city. L.S.Sya (2004) mentioned that Bangsar evolve, grow and develop personalities of its own where culture is not only the custom, attire or art of the society, it also covered lifestyle, urbanity and the way of life of a people.



The presupposition of the paper was that from the year 1906, when Malaya was still under British administration and Bangsar is first being used to plant rubber trees around Kuala Lumpur until now where it had become a residential area. During the 1950s, several companies housed their staff and families in Bangsar due to its convenient location. Government institutional buildings were built to respond to the increase in population.

Figure 1: Location of lower income and higher income group in Bangsar

The paper investigates the meaning and factors which contribute to exurbanism. It focuses on the extent of exurbanism in Bangsar and the impact of exurbanism on infrastructural facilities. The discussion based upon functionalism of the accessible road. The development of exurb Bangsar is being related to permeability of the areas. Permeability is important to determine the liveability of the area. Bangsar development history is investigated and compared with exurbanism phenomena in others places. Territoriality, public spaces and community lifestyles development in Bangsar are the main exurbanism component to study on permeability of infrastructural facilities.

14.2 RESEARCH METHODOLOGY

This paper used a material based approach. Morphological study is integrated with theory-guided content analysis. The theory-guided content analysis is a text analysis in order to search for the meaning of the studied entity. Morphological studied on the development plan guided the content analysis process. Morphological study on the planning of Bangsar and historical research will provide clues on the exurbanism Bangsar has undergone.

In theory guided analysis, the thought processes has to shift in between content and existing models of Bangsar. For example, in order to analyse a textual content whether it is suitable to be applied in exurb Bangsar, there is a need to process the analysis based on the existing phenomena in Bangsar. The observations made in the content are not considered as “findings” rather than “clues”. Discussion on past and present events in the context of the present condition is allowable by conducting historical research. Thus, reflect and provide answers to current issues and problems arises in Bangsar are possible. Historical research helps to answer questions such as: Where they come from, why Bangsar, what is Bangsar now? How is the development pattern of Bangsar?

It is the study of a phenomenon. In this paper, basic concept of exurbanism in Bangsar, a literature analysis based description on the construction of public spaces from time to time and its social background and the contents model based on the clues found from the Bangsar development in relation to the residential and commercial development is defined.

Document includes Kuala Lumpur City Plan 2020. Overlapping the maps of different years will show a comparison in terms of residential, commercial, infrastructure development, road changes with the construction of highway as well as reduction in green area. The increase and reduction of component are identified and investigated, such as the relationship of the exurban form with the infrastructural facilities, satisfaction on the infrastructure layout as well as the perspective on environment, functionality, economic development, social and cultural needs of Bangsar. References on public documents, case study, reports, newspaper, journal articles, books, review of records, observations are grouped according to its content.

The issues of re-territorialise by large scale retailers and other advanced service corporation in Bangsar, the concept and characteristic of Bangsar exurbanism and infrastructure facilities is being identified as well. What is lacking in existing accessible roads in Bangsar is being identified.

The methodological approach allows addressing some of the problems commonly encountered in the evaluations of the exurb development impact on infrastructure. Different types of core exurb assets on permeability are considered and analysed whether it is sufficient to cater for the demand of high population in Bangsar. The study is carried out not only for the quantity, but also for its quality in infrastructures. There is a relationship between infrastructure and growth of population.

14.3 PRECEDENT STUDY FOR EXURBAN DEVELOPMENT

This section described the comparative analysis of precedent study on the exurb development in Hong Kong. People are leaving big cities to search for cheaper homes. They believe that exurb has less crime, better retirement and more time for recreation.

The New Territories of Hong Kong includes the area from the north of Kowloon to the south of mainland China, as well as over 200 islands. The New Territories consists of plenty of fishing villages and villages which show a traditional image different from modern Hong Kong. The areas are less developed as compare to Hong Kong Island. However, the New Territories undergone rapid development as more commercial ventures and housing projects are presents nowadays. The New Territories houses 50 percent of Hong Kong residents.

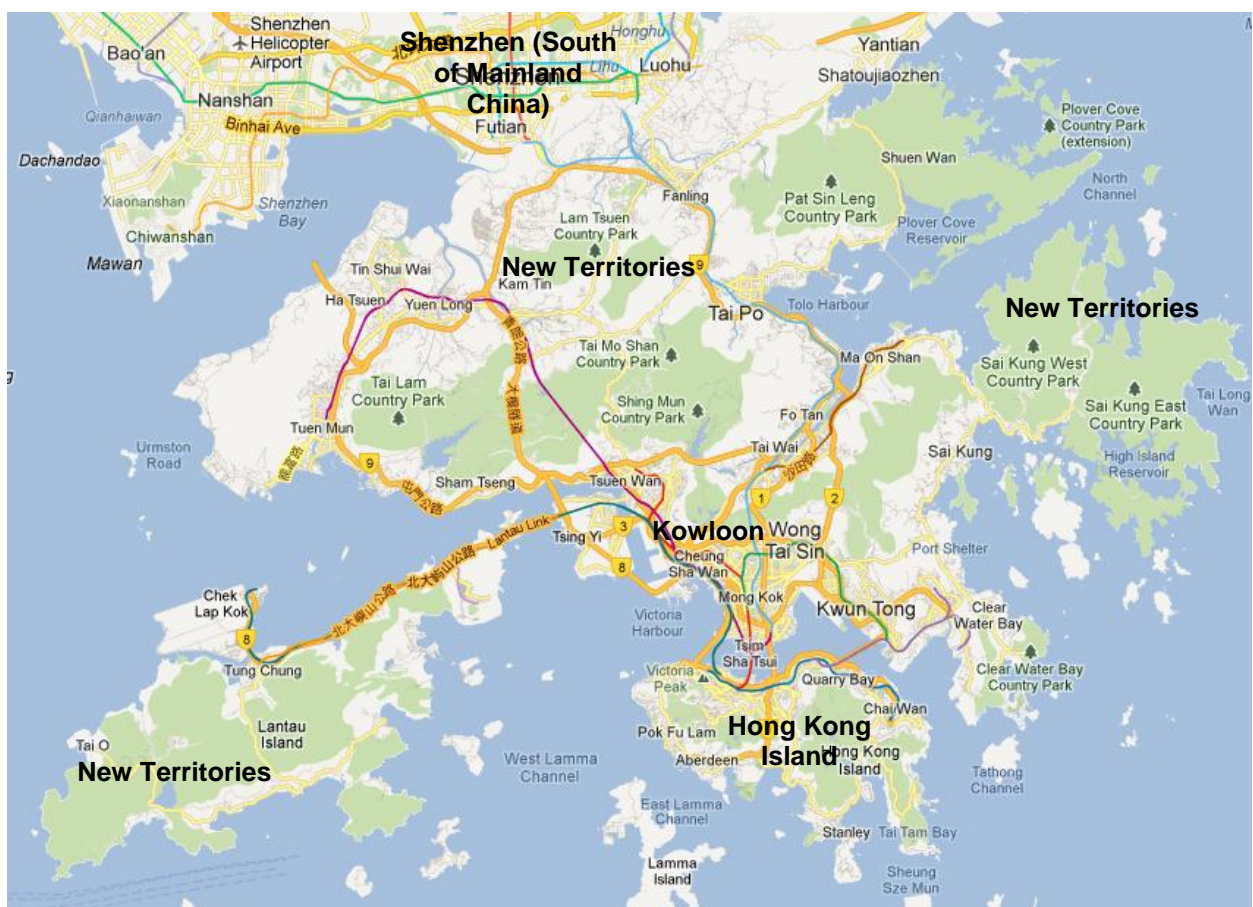


Figure 2: Location of the New Territories, Kowloon and Hong Kong Island

The drawback to live in the New Territories is the commuting time to Hong Kong Island for work. Residents in the New Territories area embroiled in a lengthy process to go for work in Hong Kong Island. However, the commute time is offset by the cheaper accommodation, greener scenery and less busier lifestyles. Furthermore, the New Territories is well-connected to the Kowloon and Hong Kong Island via the Mass Transit Railway (MTR) line, bus and ferry services.

There is a need to guide the development in exurban communities like the New Territories to prevent the spread of sprawl. Bangsar has sprawled too fast beyond rural, and more towards urban and suburban.

區議會分區	District Council district	男性 Male 數目 No.	女性 Female 數目 No.	男女合計 Both Sexes 數目 No. 百分比%	性別比率 ⁽¹⁾ Sex ratio ⁽¹⁾
香港島	Hong Kong Island	574 500	703 100	1 277 700 18.3	817 (912)
中西區	Central & Western	115 200	144 100	259 300 3.7	799 (909)
灣仔	Wan Chai	67 200	91 700	158 900 2.3	733 (874)
東區	Eastern	266 700	320 200	586 900 8.4	833 (912)
南區	Southern	125 400	147 100	272 500 3.9	853 (936)
九龍	Kowloon	965 200	1 098 700	2 064 000 29.6	878 (934)
油尖旺	Yau Tsim Mong	141 400	163 500	304 900 4.4	865 (940)
深水埗	Sham Shui Po	170 400	196 400	366 800 5.3	867 (919)
九龍城	Kowloon City	163 600	202 200	365 800 5.2	809 (905)
黃大仙	Wong Tai Sin	200 000	216 800	416 800 6.0	922 (948)
觀塘	Kwun Tong	289 900	319 800	609 700 8.7	906 (946)
新界	New Territories	1 731 500	1 905 800	3 637 300 52.1	909 (954)
葵青	Kwai Tsing	246 500	262 000	508 500 7.3	941 (972)
荃灣	Tsuen Wan	135 600	156 200	291 800 4.2	868 (933)
屯門	Tuen Mun	237 500	252 100	489 700 7.0	942 (972)
元朗	Yuen Long	265 800	290 700	556 600 8.0	915 (956)
北區	North	144 400	160 700	305 100 4.4	898 (931)
大埔	Tai Po	139 700	151 500	291 300 4.2	922 (978)
沙田	Sha Tin	291 500	327 900	619 400 8.9	889 (941)
西貢	Sai Kung	199 000	225 100	424 100 6.1	884 (949)
離島	Islands	71 400	79 600	150 900 2.2	897 (950)
合計	Overall	3 271 300	3 707 700	6 979 000 100.0	882 (940)

註釋：(1) 性別比率是指在人口中相對每一千名女性的男性數目。括號內的數字是指扣除外籍家庭傭工後
男性比率

Note : (1) Sex ratio refers to the number of males per 1 000 females in the population. Figures in brackets refer to sex ratios after excluding foreign domestic helpers.

Table 1: Land-based Non-institutional Population by District Council District and Sex, 2010. Source: <http://www.statistics.gov.hk>

The New Territories is well connected to the Hong Kong Island with variety of public transport. Government provides large networks of public transport that link the New Territories with Kowloon and Hong Kong Island. In order to encourage the use of public transport, they promote walkable community. On the other hand, Bangsar is not developing to be a walkable neighbourhood as vehicles movement is given more priority than pedestrian movement. Pedestrians have to weave in and out of all sorts of

obstacles such as hawker stalls, parked vehicles and even street signs. Pedestrian share traffic lanes with fast-moving cars or walk on uneven and neglected road reserves. They should be well-landscape and lighted such that walking experience is not only enjoyable but also safe.



Figure 3: Left: Motorbikes conquer the walkway Right: Hawker, peddlers are not properly regulated

14.4 ANALYSIS OF EXURBANISM IN BANGSAR

There are six aspects to be analysed in exurbanism of Bangsar. There are planning on land use and zoning, permeability, territoriality, re-territoriality, public space and community lifestyle. The revolution that Bangsar undergo to suit the exurban environment is relate to these aspects.

14.4.1 Planning – Land use and Zoning

Sheppard (2005) claims that planning approach of exurbia based on economics, demographics, competitor strategies and proximity to highways, rather than possibilities of public space or urban morphology. Permeability will influence land use purpose. On the other hand, land use will influence the development of road transport as well and hence increase the permeability of the development area. Integrates land use with transportation ensure transportation network are economically viable and physically accessible.

As we compare the existing and future plans, there are more commercial areas in future land use. Institutional and residential lands along Jalan Bangsar and Jalan Maarof are allowed for mixed use and commercial purposes in the future. The land along Jalan Bangsar and Jalan Maarof are highly accessible and visible. Hence, they have the potentials to be used as commercial purposes. Besides, green area is further reduces as existing green areas are allowed for residential development to cater for the growth in population. Hence, road transport will be further extending to the development area.

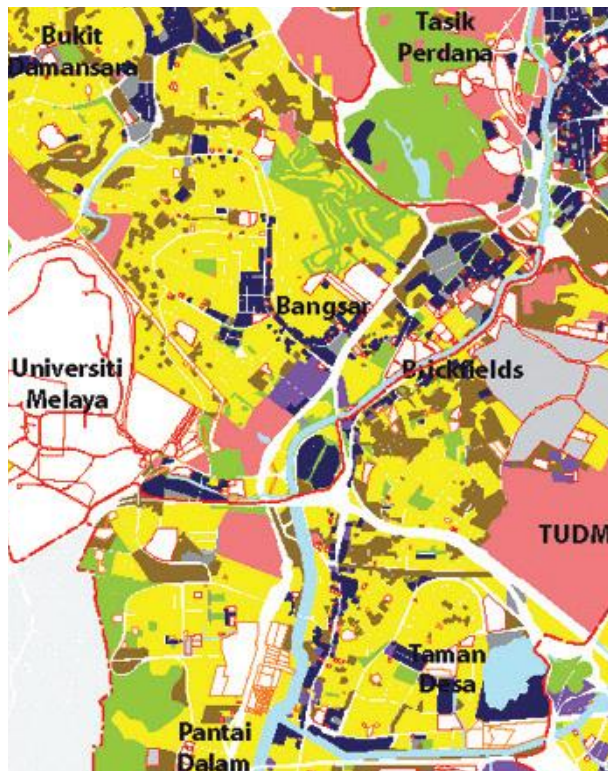


Figure 4: Existing land use, 2005

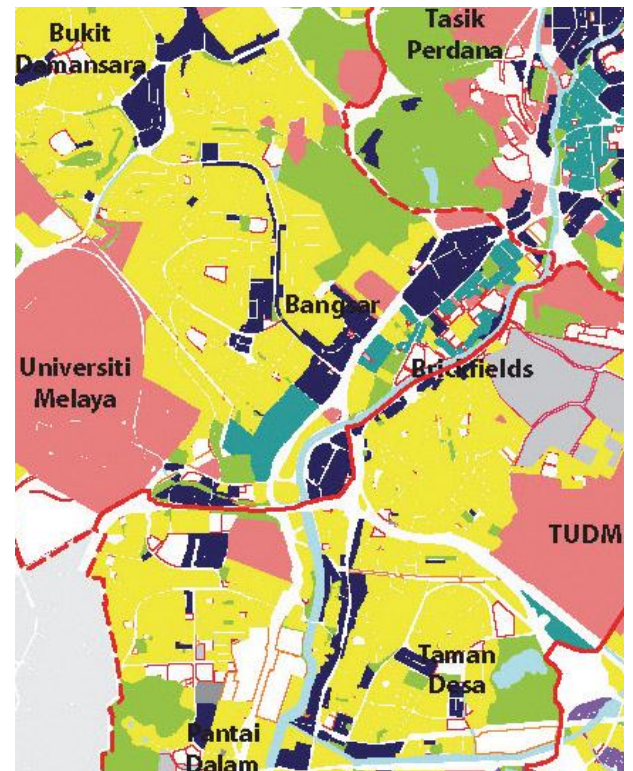


Figure 5: Future land use, 2020

Source: Kuala Lumpur City Plan 2020, 2008

14.4.2 Permeability

Public space plays an important role in linking and connecting people together. Permeability is an important component for a successful public spaces planning as this will bring people together and enhance community lifestyle. Furthermore, without quality permeable accessible roads, human movement will be limited. Hence, it determines whether it is a living city which can serve as a catalyst for exurbanism.

The Lever Brothers building was built in 1947. There are no other building coming up after Lever Brothers' building, hence, the initial Jalan Bangsar is just up to here. Besides, the first commercial block in Bangsar Baru is the McDonald's row, formerly comprising of grocery shop. Hence, the road Jalan Maarof is being constructed till Mcdonald area only.

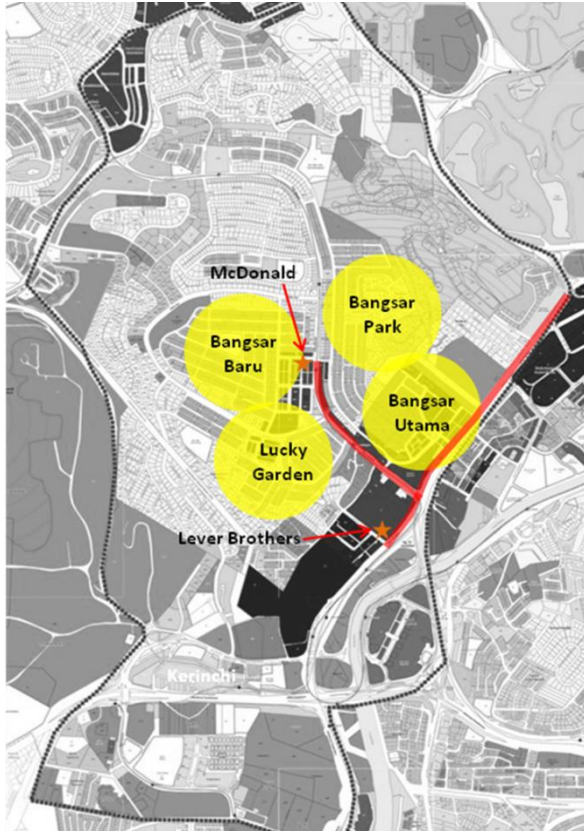


Figure 6: Earliest Housing area in Bangsar

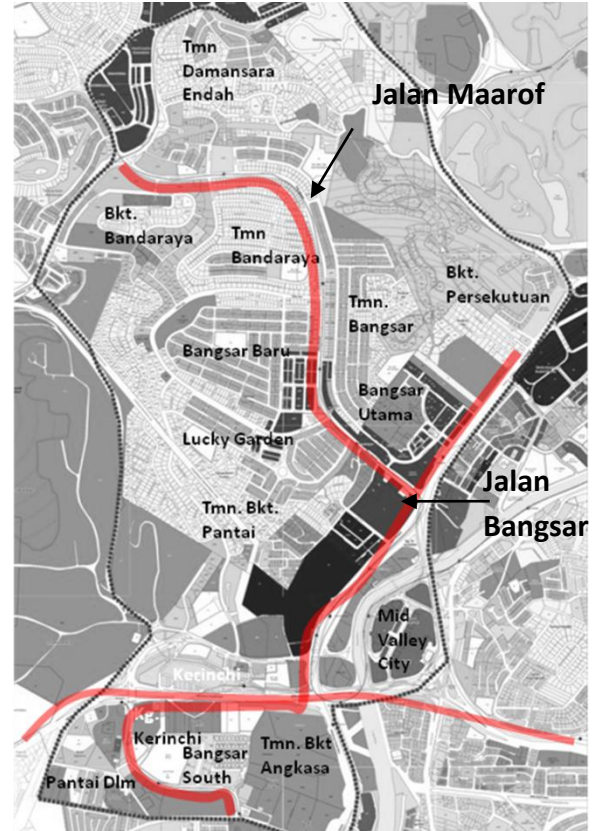


Figure 7: Existing major road linking



In 1970s, Bangsar became a housing area to cater the needs of people who work in Kuala Lumpur. Hence, more emphasis is given to improve the road network. Road transport is the main mode of transportation in Bangsar, though light rail transit (LRT), Keretapi Tanah Melayu (KTM) and others are used as transportation to some extent. This is because these public transportation services are available along Jalan Bangsar only; they do not link the residential area along Jalan Maarof with Jalan Bangsar. Jalan Maarof is Bangsar's main road which divides Bangsar neighbourhoods' into two main parts. Constructions of highway also contribute to increase in road length. It can overcome traffic congestion problem and travel time to commute into urban areas had been reduced.

Figure 8: Location of Bangsar South

The exurban Bangsar had been further extended to a 60 acre land of Bangsar South on 2007. This prove Rick Lyman (2005) statement that when there is no more land and the home prices increase, the whole cycle will be extended to another area near to the existing exurb. Developers carried out upgrading works such as widening the main access roads, construct new pedestrian walkways and landscaping works before the construction of Bangsar South. Hence, permeability is an important factor to determine the successful of a development project. The main purpose of development is to encourage people to the area and make the place liveable. The place is not easily accessible, no one is willing to go there, and the project will be a failure.

14.4.3 Territoriality of Exurb Bangsar

Acheson and Gardner (2008) argues that territories come about when groups find there are benefits of excluding other groups of competitors. Hence, territoriality can be summarise as the ownership of an area, where the owner is the person is the only restricted person to use and access the area for its own benefit and exclude others from entering the area. Furthermore, to further define territorial boundaries, certain buffer strategies such as fences, shrubs, walls and gates are used to reinforce the sense of territoriality.

One Bangsar consists of nine bungalows units in the residential area being converted into nine food outlets serving French, Thai, Japanese, Indian and Chinese food, and others. They were abandoned because the residents are unhappy with the conversion of bungalows unit along Jalan Maarof into commercial units. Bangsar residents do not welcome commercial activities to take place around their residential environment which make their housing area being too congested and commercialized. Residents want to live in a peaceful neighbourhood without disturbances like noise pollution, traffic congestion and parking woes which stem from commercial areas.



Figure 9: One Bangsar is left abandoned



Furthermore, the current situation in Telawi commercial which is always crowded with people and congested with vehicles is a nightmare for the local community. During the day, Bangsar Baru is a bustling commercial area crowded with office workers. By night time, it is one of the most happening nightspot. There are nightclubs and bars packed with locals and foreigners especially along Jalan Telawi. Hence, there are a few approaches taken by the resident association to protect their own

territorial as residential area which is located next to the busy commercial area. For example, the authority had approved their application but on condition all shops at Bangsar Baru area can run their business until 1am only.

Snatch thefts are a frequent occurrence; hence, the resident association tries to protect their territory by turning Bangsar Baru into a tightly guarded and gated community. R.H.Schneider and T. Kitchen (2007) claim that associated with types of access control is a fundamental crime prevention principle as it reduce opportunity and increase risk to the offenders. In order to do so, they permanently close off some side lanes and place barricades at each of the entry and exit points. Closing off the four lanes will cause a bottleneck and makes it easier for police to nab culprits as they have fewer escape routes. Besides, it is also improving the privacy of residential area where the barrier will serve as a buffer from the commercial area.

14.4.4 Re-territoriality of Exurb

Besides, re-territorialisation is the restructuring of a territory to be a higher quality territorial settled environment as a concept and indicator of growth in wealth. Even though Bangsar is re-territorialise by large scale retailer like Bangsar Village I and II, old family owned businesses still exist in Bangsar. There is a co-existence in Bangsar where the old family-owned business had survived under exurbanism.



Figure 10: Family owned business at Lorong Ara Kiri, Lucky Garden

According to Sheppard (2005), retail has historically been dependent on mobility, transportation and access for its success. Shoppers need a conveniently accessible, ample stocked shopping area with adequate parking. In order to remain competitive and a convenient shopping option, the downtown shopping mall began co-opting neighbouring surface lots and rooftops for additional spaces.

This phenomenon happened in Bangsar as well. Bangsar Village I & II which are located at the congested Telawi area face the problem of insufficient parking too. Hence, Bangsar Village strategy is to use the opposite basement parking on the neighbouring Bangsar food court lots as their customer parking area.

Furthermore, Bangsar Village and Bangsar shopping centre provide valet parking services where patrons just need to leave their cars at the entrance and attendants park and retrieve them. Normally, owners of expensive sports cars or luxury

automobiles use this service. Hence, it generates an air of distinction and positive customer service.

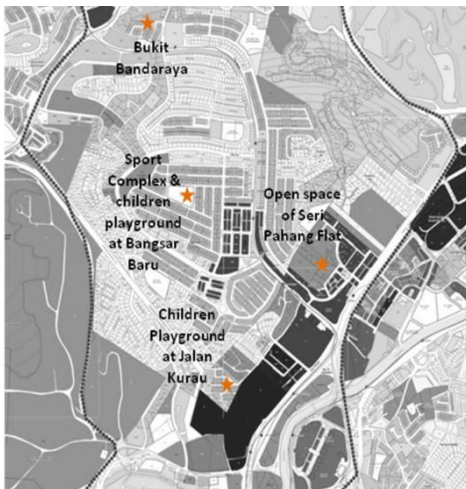


Figure 11: Saloon, Fitness Centre ant Trendy boutique at Jalan Telawi

T. Banerjee, (2001) state that shopping malls have become the new downtown and replace the main street culture of America to become the most ubiquitous and frequently visited places nowadays. However, this statement cannot be fully applied in Bangsar. This is because downtown culture at Jalan Telawi with its trendy boutique, popular coffee outlets, bistros, bars and lounge is still a favorite and popular destination for people.

As mention by Alberto, (2000), there is a need to achieve balance between human and environment in re-territorialisation. There are issues of re-territorialise by large scale retailers and other advanced service corporation in Bangsar such as Bangsar Village, Bangsar Shopping Complex, Telawi commercial area, Bangsar utama Institutional area and others. However, they blench well with the local family-oriented business. Thus achieve a balance between development and humanity.

14.4.5 Public spaces



This paper agrees with T.Banerjee (2001) who views the emergence of public spaces as a result of open space shortage. Hence, this paper seeks for the relationship of exurbanism, growth in population and public space provided in Bangsar to prove his statement that “the stock of open spaces has not kept up with population growth, especially in older core cities” .

Figure 12: Location of playground and sport Complex at Bangsar



Figure 13: Children playground at Jalan Kurau and Bangsar Baru

Bangsar lacks open spaces like playground and field. There was only one playground at Bukit Bandaraya and Bangsar Baru. Whereas in Bangsar Utama area, there is just a tiny gravel area near to the City Hall Sri Pahang Flats and an open space. Bangsar Baru has an additional facility of a sports complex. The Bangsar sports Complex opened in 1979 requires payment. This is not an ideal situation as the residents have no access and benefits to the facilities available as long as they pay for it. Children playgrounds are highly permeable as they located in the centre of housing area. However, the area of children playgrounds provided is not proportionate to the population.



Figure 14: Bangsar Village and Bangsar Shopping Complex are the community centre for Bangsar resident

Places such as shopping malls, coffee shops, bookstores, fitness centres, beauty salons, and others had been associated with the culture and exurbanism of Bangsar. Thus, act as the potential public space to provide such public life in Bangsar. However, as describe by Pine & Gilmore (1999), this public life is an economy base experience as public have to pay in order to enjoy the moment. Limited open space is provided to cater for the rapidly growth population, hence the emergence of public space is to solve the problem of insufficient open space in Bangsar.

14.4.6 Community Lifestyle

The current transportation patterns have either preceded or succeeded development of the community. A community analysis must determine how traffic patterns are constructed, or whether the traffic patterns controlled by the design of the community. This is a fundamental consideration. (Grover et al., 2010)

According to Grover et al (2010), lifestyle is a deep experience with the surrounding environment. This transportation element of community' s lifestyle applies to exurb Bangsar communities no matter on what type of public spaces. The location of public spaces and the surrounding transportation patterns can influence access to and use of the public spaces, together with the operation hours and services provided will influence the community lifestyles.

Road transport being provided will influence the choice of transportation method by community residents. Currently, Bangsar area are not fully pedestrianise, hence, residents will prefer vehicle as their mode of transport. Jalan Maarof serves as the main road to link the whole Bangsar together. The housing area are located along jalan Maarof and spread further and deeper inside. The public spaces such as shopping centres are located along jalan Maarof which serve as the main road for Bangsar, hence, it is highly visible and accessible. On the other hand, open space such as children playground and sport complex are strategically located in the centre of housing area as the main purpose of these space is to serve the resident.

Spas and fitness centre, beauty salons, boutiques, Bistro, Restaurant, Bars, Café are nestled in Telawi area. Nightlife at Bangsar is very attracting due to the variety of shops available there. Besides, there is a phenomenon of old practices blend with the new. For example, traditional Night market, Chinese restaurants, Mamak stall selling Indian & malay foods, banana leaves, and others traditional food and culture are blending well here. Lifestyle includes a wide range of characteristics contributing to any community's heritage and uniqueness. (Grover et al., 2010)



Figure 15: Night market and mamak culture along Lorong Ara Kiri 1, Lucky Garden

14.4.7 Theoretical Proposition

Theoretical analysis is carried out to further define the exurban phenomena happened in Bangsar. Sheppard (2005) mentioned that the version of public space in exurbia is composed of fleeting encounters of drivers jockeying for parking spaces, utilitarian dialogues at drive-thrus, and perfunctory exchanges at point-of-purchases. When road construction couldn't keep up with the population growth, traffic had become a nightmare. People can hardly find a parking here. Hence, illegal parking such as parking on the yellow line and double parking issues may occurs.



Figure 16: Traffic Congestion at Bangsar Baru

David Brooks (2004) as a supporter of exurbs mentioned that exurbs provide a high quality of life and has attracted both upper-income families who live expansive lifestyles and middle and lower-income families who move to the far fringes of metro areas because it allows them to step up the ladder to a bigger house, better schools, and a nicer life than they could afford closer in.

Besides, there are lower income families staying at the flat at Bangsar Utama and Kerinchi area. As a result, there is a social gap in between the poor and wealthy people. Bangsar starts develop from the area near to the railway, and develop deeper inside from the railway station. These give us a clear image on the important of transportation infrastructure in affecting the development of a place. This is because people will choose to stay near to the core of transportation facilities as this will bring more convenient to the people activities.

14.5 CONCLUSION

With the rise of automobiles, sub-urbanism happened and follows by its later stage of exurbanism. Followed by a rapid growth in population, road transport serves as the easiest way to link people and connect places together. It had successfully serves as a catalyst for exurbanism to happen. Hence, Bangsar had become a diverse city different from what it is in the past. Furthermore, the extent of exurbanism in Bangsar had further extended to Bangsar South since 2007 as there is not much empty land available for development in Bangsar area. There may be others development coming up next as an extension of the exurbanism in Bangsar to cater for the rapid growth in population.

According to researchers, exurb is lying in between urban or suburban and rural. Bangsar with its high population and limited land available nowadays is going too far beyond rural. However, rather than suburban, I would consider Bangsar to be urban as it had been developed into a very compact residential area with mushrooms of apartments and condominiums all over the skyline and hence make Bangsar become a high density area.

The paper leads us to rethink on how future Bangsar should look in the globalization age. Exurbanism of Bangsar can be made more liveable with a better exurb living quality by fostering the cultural values and community lifestyles that creates the sense

of place of the future Bangsar.

The function of building changes, the people living there changes, the exurb landscape changes, the road changes, the public spaces changes and all these dynamics mean news exurban form of Bangsar must be continually studied and analysed. Over time, regular content analysis provides a historical record of exurbanism that can guide decision-making in the future. Furthermore, the findings on exurbanism in Bangsar can be generalised to other urban centres of Malaysia such as Penang and Johor Bahru to serve as a “clues” for other research on exurban living community.

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